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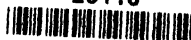
EDITORS

EUGENE S. MCCARTNEY  
HENRY VAN DER SCHALIE

VOLUME XXVI (1945)  
PART I BOTANY AND FORESTRY

"Pusilla res mundus est nisi in illo  
quod quaerat omnis mundus habeat."  
- SENECA, *Naturalis Quaestiones*

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LONDON: GEOFFREY CUMBERLEGE OXFORD UNIVERSITY PRESS

1947

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**Set up and printed,  
August, 1947**

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# **BOTANY**





# PACIFIC SPECIES OF GALAXAURA

## II. SEXUAL TYPES \*

RUTH CHIEN-YING CHOU

### INTRODUCTION

**B**ECAUSE of space limitation the first part of this paper, dealing with the asexual forms of *Galaxaura* in the Pacific, was separated from this second part, which covers the sexual forms. No real harm was done by the separation, because the sexual and the asexual forms of each species have not been associated with certainty as alternating phases in the life cycles of the actually existing natural species. The sexual and the asexual phases differ not only in the reproductive organs that they bear, but also in certain anatomical features that are restricted to one phase or the other. Consequently many more species are of necessity recognized than actually exist. When life-history studies shall have shown which sexual and asexual forms are to be associated, such an investigation as this will cease to be justifiable.

The goal of systematic studies of *Galaxaura* (and of other genera as well) is to unify and complete our knowledge of the natural species. Every proved association will eliminate a name from the literature, and eventually there will remain only a minimum number of species known only in one phase. In the meantime, however, primary division into sexual and asexual forms, with keys to each series, will prove the most practical and effective way of systematizing the types of the genus.

### KEY TO THE SEXUAL FORMS OF GALAXAURA IN THE PACIFIC

#### SEXUAL TYPES

Plants sexual or cystocarpic; branches terete throughout or flattened above, villous or glabrous; cortical tissue parenchymatous, composed of a continuous

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\* Papers from the Department of Botany and the Botanical Garden of the University of Michigan, No. 749.

Part I of this article was published in *Pap. Mich. Acad. Sci., Arts, and Letters*, 30 (1944): 30-56.

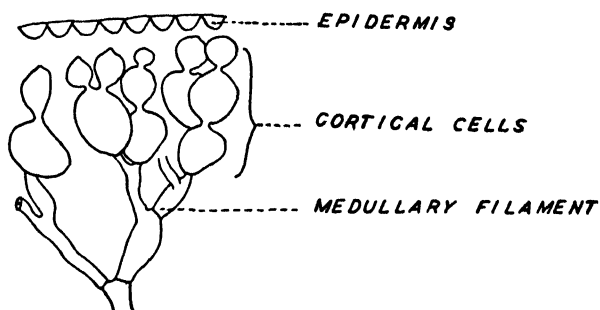


FIG. 1. Type of the Oblongatae

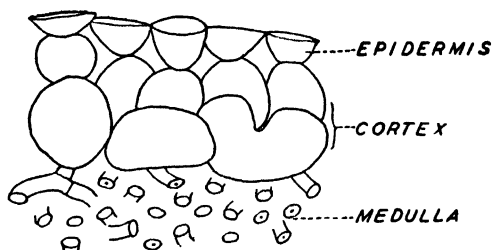


FIG. 2. Type of the Squalidae

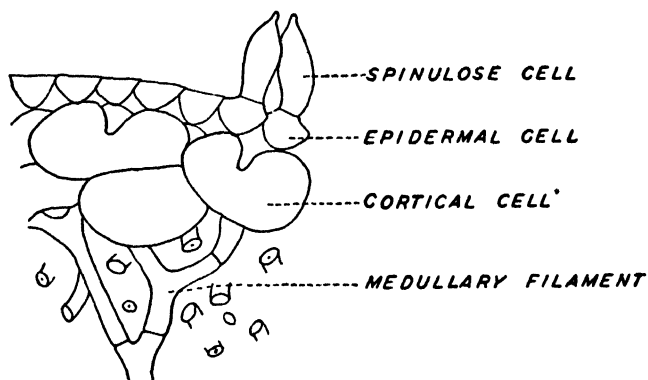


FIG. 3. Type of the Vepreculae

epidermis of chromatophore-bearing cells and a hypodermis of two or three layers of cortical cells which are either loosely arranged and subfilamentous as typified by the Oblongatae<sup>1</sup> (Fig. 1) or compactly and parenchymatously as ex-

<sup>1</sup> With regard to the innovations in sectional nomenclature, necessitated by the inconsistent and incorrectly formed names previously used, see Part I, p. 37.

emplified by the Squalidae (Fig. 2), the Vepreculae (Fig. 3), and the Angustifrones.

1. Plants with branches terete throughout; cortical tissue with or without lobed cells, when present the latter innermost . . . . . 2
1. Plants with branches flattened above, although terete below; lobed cells when present intermediate in position . . . . . 7
2. Branches glabrous or subglabrous; cortical tissue parenchymatous or subfilamentous . . . . . 3
2. Branches villous or hirsute; cortical tissue tristromatic; lobed cells present . . . . . (Section Squalidae) 6
3. Cortical tissue subfilamentous, remaining attached to medullary filaments after decalcification . . . . . (Section Oblongatae) 4
3. Cortical tissue parenchymatous . . . . . (Section Umbellatae) 5
4. Branches slender, commonly 0.5-1.0 mm., seldom exceeding 1 mm. in diameter . . . . . *G. cylindrica*
4. Branches coarse, 0.8-2.5 mm., commonly exceeding 1 mm. in diameter . . . . . *G. oblongata*
5. Segments short, annulate-rugose, 1-2 mm. in diameter, seldom exceeding 5 mm. long, nodes constricted . . . . . *G. rugosa*
5. Segments long, smooth, 2-4 mm. in diameter, 0.5-2.5 cm. long, nodes articulate . . . . . *G. umbellata*
6. Branches hirsute, extended assimilatory filaments scattered singly, slightly stiff and brittle; epidermal cells 24-44  $\mu$  in diameter (surface view) . . . . . *G. glabriuscula*
6. Branches villous, at least below; extended assimilatory filaments often fasciculate; epidermal cells 12-24  $\mu$  in diameter (surface view) . . . . . *G. squalida*
7. Epidermis bearing spinulose cells; cortical tissue with lobed cells present . . . . . (Section Vepreculae) 8
7. Epidermis smooth, without spinulose cells; cortical tissue with or without lobed cells . . . . . (Section Angustifrones) 9
8. Thallus chalky, strongly spinulose, 1-2 mm. wide . . . . . *G. veprecula*
8. Thallus smooth, surface shiny, spinulose on the thickened margins only, 2-3 mm. wide . . . . . *G. ventricosa*
9. Cortical tissue tristromatic, lobed cells present, segments short, commonly not exceeding 1 cm. long . . . . . *G. angustifrons*
9. Cortical tissue 3- to 4-stromatic, without lobed cells; segments 1.0-2.5 cm. long . . . . . *G. intermedia*

*Galaxaura cylindrica* (Ell. & Sol.) Lamouroux. — Pl. I,

Figs. 1-12; Pl. VIII, Fig. 1

*Corallina cylindrica* Ellis & Solander, 1786, p. 114, pl. 22, fig. 4; *Galaxaura cylindrica* Lamouroux, 1812, p. 22, pl. 22, fig. 4; Kjellman, 1900, p. 64, pl. 8, figs. 34-42, pl. 20, fig. 53; Børgesen, 1916, p. 106; 1927, pp. 77-78; Taylor, 1928, p. 138.

Plants densely bushy, up to 10 cm. or more high, attached to the substratum by a discoid holdfast; basal part short-caulescent, upper branches erect, angles narrow, more or less regularly dichotomous, sometimes subpinnate and subexcurrent, with main axes slightly coarser than the lateral ones; segments 5 to 10 mm. long, 0.5 to 1.0 mm. in diameter, terete, faintly rugose; proliferations single or stellate; medullary filaments 8 to 11  $\mu$  in diameter, toward the periphery closely and anticleinally branched with each ultimate branch terminated by two or three large subglobose or ellipsoidal closely arranged cells forming a pseudoparenchymatous cortical tissue; cells of pseudoparenchyma gradually diminishing in size outward; cells of the innermost layer subglobose or sometimes compressed and orbicular, 18 to 24  $\mu$  in diameter, each bearing one or two ellipsoidal or subglobose cells toward the outside, 5 to 25  $\mu$  high, 10 to 18  $\mu$  broad, often taller than wide, each in turn bearing one or two small subglobose cells 7 to 11  $\mu$  in diameter, forming a subepidermal layer; cells of the outermost layer (epidermis) strongly laterally coherent, parenchymatous, peeling off readily in sheets after decalcification, angular in surface view, semilunate in section, 8  $\mu$  high, 10 to 12  $\mu$  wide at the outer wall, chromatophore-bearing; conceptacles globose, embedded in the thallus, discharging by ostioles. (The specimens bear only immature reproductive bodies.)

The distinction between *G. cylindrica* and *G. oblongata* seems rather arbitrary, for the two plants are anatomically so similar that even experts fail to point out any noteworthy differentiating features that can be counted as valid specific characteristics. They are separated entirely on the basis of the diameter of the branches, that is, in *G. cylindrica* the branches are very slender, commonly not exceeding 1 mm. in diameter, whereas *G. oblongata* has branches from 1 mm. up in diameter. This characteristic alone naturally is hardly adequate for specific distinction; phycologists generally seem to agree, however, in accepting these two classical species, even when they do not agree upon accepting the numerous "Eugalaxaura" species proposed by Kjellman. Therefore the present identification of species from the Philippine Islands is likewise based solely on the relative diameter of the branches in material referred respectively to *G. cylindrica* and *G. oblongata*.

Kjellman, Børgesen, and others have all reported that the branches of *G. cylindrica* range from 0.5 to 0.75 mm. in diameter, a measure-

ment which is less than I have found in the Philippine plants, in which at least some of the branches reach 1 mm. However, when compared with other plants which I have called *G. oblongata*, the branches of these plants are definitely more slender; therefore I have decided to set the boundary between these two closely related species at 1 mm. If the slightly greater diameter of the Philippine plants holds good when more material comes to light, further studies may indicate that West Indian and Philippine plants are distinguishable.

*Type locality.* — West Indies.

*Specimens studied.* — PHILIPPINE ISLANDS: Dalupiri Island, Babuyan Group, *Bartlett 14981*, Oct. 31—Nov. 5, 1935; Batan Island, Batanes Group, *Bartlett 15416*, July 20, 1935.

*Further distribution.* — Bermuda, West Indies, warmer Atlantic coast of America, Red Sea.

*Galaxaura oblongata* (Ell. & Sol.) Lamouroux. — Pl. II, Figs. 1–16; Pl. III, Figs. 1–14; Pl. IX, Figs. 1–2

*Corallina oblongata* Ellis & Solander, 1786, p. 114, pl. 22, fig. 1; *Galaxaura oblongata* Lamouroux, 1816, p. 262; Børgesen, 1927, pp. 71–77, figs. 39–41; Taylor, 1928, p. 139, pl. 21, fig. 5; 1941, p. 95; 1942, p. 84; 1945, pp. 142–143.

Plants forming dense round tufts 4 to 12 cm. or more high, attached by small discoid holdfasts; branching regularly dichotomous; branches fastigiate or spreading, glabrous, distinctly calcified, brittle and fragile when dried; segments cylindrical, 0.4 to 2.5 cm. long, 0.8 to 2.5 mm. in diameter, more or less annulately rugose, nodes fractured, constricted, or subarticulate, the diameter of the branches in a single plant uniform, but varying greatly between plants; proliferations common, single or stellate, present at nodes or internodes where the epidermis is ruptured; medullary filaments 4 to 12  $\mu$  in diameter, toward the periphery anticlinally and closely branched, each ultimate branchlet terminated by two to three subglobose cortical cells (excluding epidermal cells), connected successively by a narrow protoplasmic strand, thus cells of each branchlet remain attached after decalcification, the inner one or two cortical cells the largest, the basal cell subglobose or slightly compressed, wider than high, 20 to 40  $\mu$  in diameter, each bearing two cells, rarely a single oblong, obovate, or subglobose one, 16 to 36  $\mu$  tall, 12 to 32  $\mu$  wide, these in turn each bearing one, sometimes two small, subglobose cells, 8 to 18  $\mu$  in diameter, below the epidermis; epidermal cells closely arranged,

peeling off in sheets after decalcification, in surface view angular, 8 to 20  $\mu$  in diameter, in section semilunate; reproductive bodies common, male and female conceptacles globose, embedded in the cortical tissue, opening outwardly by an ostiole; spermatangia small, globose, about 4  $\mu$  in diameter, or elliptical, 20  $\mu$  long, 6  $\mu$  in diameter; female conceptacles large; production of first carposporangium sometimes followed by proliferation of a new carposporangium within the empty sporangial wall, and several sporangia may be successively proliferated as the growing season progresses; mature carposporangia large, oval or obpyriform, size variable, 16 by 20  $\mu$  to 50 by 70  $\mu$  in diameter.

From the numerous specimens examined I noted that some are so very fragile (*Bartlett 14248*) that they could easily be called *G. fragilis*; some have fastigiate branches which would go nicely with *G. fastigiata*; and some have very coarse branches which do not look the least like the others except for their anatomical structure. When I laid them all out, however, I found the variations overlapping. There are specimens of intermediate types to bridge over the extremes, so that it is impossible to draw any specific line that would include one and not exclude another.

If geographical distribution or range of these plants were to play a rôle in the determination of the species, then the plants from the Philippine Islands might be called *G. fastigiata*, since it is the type region for that species. However, my observations have led me to think that *G. fastigiata* is probably a physiological form, that is, the plant may have been grown under such favorable conditions that all the branches received equal chances for development, and therefore became equally tall, so that when pressed they appeared fastigiate. Under less favorable conditions, on the contrary, when normal growth is being constantly interrupted the branching becomes subpinnate, and the branches are unequal in length and in diameter. Both of these states have been observed among the Philippine plants at hand. Furthermore, under *Bartlett 14980* there are the robust, the fastigiate, and the subpinnate forms, all merging into one another along a gradient which would allow sufficient variation for different phases to be considered different species if one met them singly. Besides, there are two specimens, *Bartlett 16185* and *16200*, from Cebu Island, which externally do not look the least like any other *G. oblongata* from the vicinity. The plants are small, heavily calcified, with short poculiform or club-shaped internodes; so that at

first I was strongly inclined to treat them as new, but when carefully examined they were found to be only young plants structurally identical with those of *Bartlett* 14980, which I have called *G. oblongata*.

Because of the structural similarity I regarded the *Oblongatae* at hand whose branches exceed one millimeter in diameter as *G. oblongata*, and those below one millimeter as *G. cylindrica*. *G. oblongata*, as I have interpreted it, may in the future turn out to be species complex, embracing the sexual phases of more than one species, or perhaps even the species of a distinct genus or subgenus with several haplobiontic species. However, it must be admitted that at present it is not possible to segregate them.

*Type locality*. — "West Indies."

*Type specimen*. — "Ellis and Solander's specimen no longer exists."

*Specimens studied*. — MEXICO: Near Isla María Magdalena, dredged at depths of 5.5 and 21.5 meters, *Taylor* 39-667A and 39-653, May 9, 1939; ECUADOR: Bahía San Francisco, Esmeraldas, *Taylor* 34-485, Feb. 11, 1934; PHILIPPINE ISLANDS: Dalupiri Island, Babuyan Group, *Bartlett* 14607, July 17; and 14980, Oct. 31—Nov. 5, 1935; Luzon, Subic Bay, Subic, Zambales Province, *Bartlett* 14140, May 31, 1935; Sinaít, Ilocos Sur Province, *Bartlett* 14237, 14248, June 2, 1935; *Moises Kalaw* 6, June 12, 1935; Cavite Province, *Bartlett* 14585, July 7, 1935; Wawa, Nasugbu, Batangas Province, *J. V. Santos* 120, July 14, 1935; Mindoro, Puerto Galera, *Bartlett* 13778, 13785, May 12-17, 1935; Cebu Island, Liloan Beach, *Bartlett* 16185 and 16200, Sept. 20, 1935; JAVA: Eiland Kerkhof, Baai van Batavia, *Kostermans* 32, Sept. 26, 1938; SUMATRA: Belimbing (south coast of Sumatra), *Kostermans* 773, Oct. 20, 1938.

*Further distribution*. — Florida, Dry Tortugas, West Indies, Brazil, Adriatic Sea, Red Sea, Australia, Timor, Hainan Island, Hong Kong, Japan.

*Galaxaura squalida* Kjellman. — Pl. IV,  
Figs. 1-11; Pl. VIII, Fig. 2

Kjellman, 1900, pp. 55-56, pl. 6, figs. 1-12, pl. 20, fig. 9; Børgesen, 1916, pp. 102-105, figs. 108-111; Taylor, 1928, p. 140, pl. 21, fig. 18, pl. 31, fig. 4; 1942, p. 84; 1945, p. 142.

Plants bushy, up to 10 cm. or more high, attached by a broad discoid holdfast; branching dichotomous, angles narrow or acute;



branches terete, villous, the upper more or less glabrous; segments 0.5 to 2.0 cm. long, 1 to 2 mm. in diameter, annulate-rugose, basal ones often short, closely forking (the branches thus appearing quasi-umbellate); proliferations solitary or geminate, base cupuliform; extended assimilatory filaments fasciculate, fascicles evenly distributed or subverticillate toward the apex of the branches, seldom exceeding 1 mm. long, diameter 15 to 18  $\mu$ , composed of short cylindrical cells 1.5 to 2.0 times as long as broad; medullary filaments 7 to 18  $\mu$  in diameter, cortical tissue parenchymatous, tristromatic; cells of the innermost layer the largest, more or less globose, 22 to 40  $\mu$  in diameter, some 2- or 3-lobed, and their diameter one to two times wider than high; cells of the intermediate layer smaller, globose or ovate, 18 to 25  $\mu$  in diameter; cells of the outermost layer (epidermis) closely arranged, of two kinds: either (a) angular in surface view, 14 to 22  $\mu$  in diameter, in section semilunate, 10 to 15  $\mu$  tall by 18 to 25  $\mu$  broad at the outer wall; or (b) circular and slightly elevated above the general level of the surface (these may be the basal cells of extended assimilators identical with what others call "abortive cells"); conceptacles spherical, embedded in the medullary layer, with ostioles opening through the cortical tissue; carposporangia ovate or elliptical, about 50  $\mu$  long by 30  $\mu$  in diameter.

In the section Squalidae (Microthoë) Kjellman distinguished a West Indian plant as *G. squalida* and a Japanese plant as *G. cuculligera*; the latter is characterized by having cucullate proliferations. This segregation has been adopted by most modern workers, and the plants from Pacific waters recorded under the name *G. cuculligera* (as, for example, by Weber-van Bosse, Butters, Tanaka), and those from the Atlantic as *G. squalida* (by Collins and Hervey, Howe, Borgesen, Taylor).

The presence of *G. cuculligera* has been recorded by Japanese workers, but the occurrence of *G. squalida* in the Pacific Ocean, so far as I can trace it, has not hitherto been noted. Nevertheless, in the Philippine materials that I have examined there are some plants which bear cucullate branches and others which do not. Structurally, however, I have not been able to detect any noteworthy differences between the two, so that, presumably, the cucullate condition may have been brought about by a sudden interruption of the normal rate of growth. This condition is evident in *Bartlett 14982*, for here one can readily see that the older part of the plant is very muddy. It

seems that the plant was for a time buried in mud or covered by it and that the new growth regenerated from the center of the axis, so that the basal part was surrounded by the peripheral tissue of the older branch — a state which is similar to regeneration of the lost parts. Furthermore, since the cucullate state also appears on the West Indian plants, as well as being common to other species of Squalidae, since it is absent in some of the Philippine plants, and since microscopical examination yields no evidence for the separation of the two forms, I am in this case adopting a broader view of the species and refer these Philippine plants to *G. squalida*, viewing the cucullate condition in some specimens as ecological or physiological and regarding it as having been brought about by external factors.

*Type locality*. — St. Croix, Virgin Islands.

*Type specimen*. — In Areschoug's herbarium, under the name *G. rugosa*.

*Specimens studied*. — PHILIPPINE ISLANDS: Dalupiri Island, Babuyan Group, *Bartlett* 14982, Oct. 31 — Nov. 5, 1935; Lubang Island, Mindoro, *Villaflores* 6, 7, 8, Aug. 24, 1935; SOCIETY ISLANDS: Tahiti, *Brooks* in Taylor herbarium 20495, Dec., 1932; PANAMA: Bahía Honda, *Taylor* 39-130, March 26, 1939.

*Further distribution*. — Bermuda, Florida, Bahamas through the West Indies to the Virgin Islands.

*Galaxaura glabriuscula* Kjellman. --- Pl. IV,

Figs. 14-20; Pl. X, Fig. 1

Kjellman, 1900, p. 56-77, pl. 7, figs. 1-2, pl. 20, fig. 26; Butters, 1911, pp. 175-176; Tanaka, 1936, pp. 151-152, figs. 12-13, pl. 37, fig. 1.

Plants with branches up to 9 cm. or more high, the basal attachment not seen; branches often much crowded above, forming corymbose or flabelliform tufts; the lower part hirsute, the upper sparingly hairy or often subglabrous, apex smooth and glabrous; segments ranging from 2 or 3 mm. to 15 (or more) mm. long, 0.8 to 2.0 mm. in diameter; proliferations solitary, base cucullate, inconspicuously encircled by a tuft of extended assimilatory filaments; the central axis traversed by few loosely entangled filaments 7 to 16  $\mu$  in diameter; cortical tissue parenchymatous, tristromatic, about 80  $\mu$  thick; cells of the innermost layer the largest, subglobose, often slightly wider than high, diameter 30 to 48  $\mu$ , some 2- or 3-lobed, one or two times

wider than high; cells of the intermediate layer smaller, subglobose, loosely arranged with intercellular spaces filled with lime, diameter 28 to 44  $\mu$ , containing stellate chromatophores each with a pyrenoid at the center; cells of the outermost layer forming the epidermis, closely arranged, parenchymatous, angular in surface view, 28 to 36  $\mu$  in diameter, in section semilunate, 12 to 16  $\mu$  tall, 28 to 40  $\mu$  wide, including the outer wall; extended assimilatory filaments evenly distributed, slightly stiff and thus easily fractured, shaft simple or branched, basal part 15  $\mu$ , apical part 18  $\mu$  in diameter, cells one and one half to two times as long as the diameter; hair-bearing epidermal cells slightly raised above the level of the surrounding epidermal cells, circular in surface view, with a circular perforation when the hair becomes detached; conceptacles spherical, embedded in the thallus, discharging through small ostioles; carpospores clavate or pyriform.

The Javanese plants which I assign to *G. glabriuscula* are very much like *G. squalida* in habit, but differ anatomically in the following respects:

The epidermal cells of *G. glabriuscula*, in general, are larger than those of *G. squalida*, that is, those of the former commonly range from 28 to 44  $\mu$  in diameter, whereas those of the latter rarely exceed 20  $\mu$  in diameter. The lobed cortical cells in *G. glabriuscula* are more common and larger than those of *G. squalida*. The extended assimilatory filaments of *G. glabriuscula* are few, thinly scattered, relatively stiff and brittle in texture when compared with those of the closely related species. Lastly, the presence of yellow pigment in the chromatophores has been regarded by several writers as unique in this species.<sup>2</sup>

The yellow color, however, is not particularly noticeable in the present Javanese plants, but microscopical examination does show the presence of a yellowish tinge in the chromatophores. If it should prove that the species is characteristically yellow, then the yellow-tinted chromatophore in these plants indicates that they did contain

<sup>2</sup> Ordinarily I am not much in favor of using color as a criterion for specific determination in Galaxaura, but since the presence of a yellow pigment has been mentioned by every author who describes *G. glabriuscula* and since this yellow color is different from other pigments which one finds in the red algae, I have tentatively decided to accept a color character in this case and have assigned these plants from Java to *G. glabriuscula*. It is possible, if the presence of yellow pigment is alternative to the presence of red in the red algae, that there may be other yellow types, perhaps yellow varieties or ecological variants of red species.

yellow pigment, but failed to retain more than a trace of it because they were preserved in formaldehyde before mounting.

*Type locality*. — Tahiti.

*Type specimen*. — In Areschoug's herbarium under the name *Galaxaura rugosa*.

*Specimens studied*. — JAVA: Eiland Kêlapa, Duizend-eilanden, *Kostermans 254*, Oct. 5, 1938.

*Further distribution*. — Bonin Islands, Tahiti, Hawaiian Islands.

*Galaxaura rugosa* (Ell. & Sol.) Lamouroux. — Pl. IV,  
Figs. 12-13; Pl. X, Fig. 2

Kjellman, 1900, p. 55; Børgesen, 1915 20, p. 100, figs. 105-106; Howe, 1920, p. 558; Taylor, 1928, p. 140, pl. 21, fig. 16, pl. 30, figs. 2, 10; 1941, p. 95; 1942, p. 84.

Plants up to 4 cm. high; branching regularly dichotomous; segments short, 2 to 5 mm. long, 1 to 1.5 mm. in diameter, terete, glabrous, distinctly annulate-rugose, continuous or constricted at the nodes; medulla composed of loosely entangled filaments 7 to 15  $\mu$  in diameter; the cortical tissue tristromatic, cells of the innermost layer largest, some 2- or 3-lobed, others globose or subglobose, often slightly wider than tall, 20 to 40  $\mu$  high, 30 to 40  $\mu$  in diameter; cells of the intermediate layer smaller than the inner ones, subglobose or obovate, 25 to 30  $\mu$  tall, 15 to 22  $\mu$  in diameter, containing stellate chromatophores with a pyrenoid at the center; cells of the outermost layer (epidermis) angular in surface view, 18 to 26  $\mu$  in diameter, in section semilunate, 8 to 15  $\mu$  tall, 18 to 22  $\mu$  in diameter, containing well-developed chromatophores; conceptacles spherical, embedded in the thallus, with ostioles opening through the thin cortical parenchymatous tissue; reproductive bodies immature.

The determination of this single specimen from Batan Island, Philippines, may seem unnatural, for it is commonly accepted that *G. rugosa*, based on a plant from Jamaica, is limited to the Atlantic waters, and similar Pacific plants have been given the name *G. elongata*. According to the type description, however, Agardh's *G. elongata*, based on plants from Tonga and Australia, was much taller and larger than *G. rugosa*. It was described as 3 to 6 inches tall, with branches as thick as a "crow's quill," whereas the present Philippine plant is only 3 to 4 cm. high, with branches commonly 1.0 to 1.5 mm in diameter.

As for Lamouroux's *G. rugosa*, it was based on Ellis and Solander's plant from the Jamaican coast, which was well illustrated by Plukenet (1691, pl. 168, fig. 4). Having compared the Batan Island plant with Plukenet's illustration of the Jamaican plant, without the least doubt I consider this Philippine plant to be identical with the West Indian one and therefore it is referred to *G. rugosa* (Ell. & Sol.) Lamouroux.

Opinion of taxonomists in the field seems to agree that *G. rugosa* is distinguished from other closely related species of the Rugosae in having branches distinctly annulate-rugose and more or less glabrous, with little or no development of extended assimilatory filaments. The present determination of a single specimen from Batan Island is based upon these two characteristics.

This Philippine plant (*Bartlett 15410*) agrees closely with Børgesen's description of the West Indian plant, except that it is very smooth, without any visible extended assimilatory filaments. Microscopical examination of the epidermal cells shows, however, the presence of circular cells which are slightly raised above the level of the angular epidermal cells and suggests potential or abortive basal cells corresponding to extended assimilatory filaments.

The branching of *G. rugosa* is very regularly dichotomous, being much more regular than that of the closely related species *G. glabriuscula* and *G. squalida*. In texture the plant is rather delicate, with wall of the thallus thinly membranous, and therefore rather fragile after decalcification.

*Type locality*. — Jamaica, British West Indies.

*Specimens studied*. — PHILIPPINE ISLANDS: Beach at Basco, Batan Island, *Bartlett 15410*, July 20, 1935.

*Further distribution*. — Florida, Bahamas through the West Indies to the Virgin Islands.

*Galaxaura umbellata* (Esp.) Lamouroux. — Pl. V,

Figs. 1-6; Pl. XI, Fig. 1

*Tubularia umbellata* Esper, 1830,<sup>3</sup> p. 125, *Tubularia*, pl. 17, figs. 1-2; *Galaxaura umbellata* Lamouroux, 1812, p. 185; Lamouroux, 1816, p. 262; J. G. Agardh, 1876, p. 526; Kjellman, 1900, p. 88 (only the name mentioned).

<sup>3</sup> *Tubularia umbellata* was cited by Lamouroux (1812) as having been published in "Esper Zooph., tab. 17, fig. 1-2." I have not been able to obtain this work, and so cannot give the exact title and date. However, both the descrip-

Plants forming tufts 5 to 6 cm. high; branches terete, glabrous, fastigiate, one to three or more times dichotomous, angles narrow and branches erect; thallus thin-walled, membranous, slightly nitent, segments 0.5 to 3.0 cm. long, 2 to 4 mm. in diameter, subarticulate or strongly constricted at the nodes; apex round with the growing point restricted to a tiny perforation in the center; medulla traversed by few loosely interwoven filaments 7 to 16  $\mu$  in diameter, cortical tissue tristromatic, cells of the innermost layer the largest, often compressed, more or less rectangular in section, commonly wider than high, 40 to 90  $\mu$  in diameter, 30 to 36  $\mu$  tall; cells of the intermediate layer variable, some subrectangular, like those of the innermost layer, some subglobose, 18 to 22  $\mu$  high, 20 to 40  $\mu$  wide; cells of the outermost layer closely arranged, forming an epidermis, in surface view angular, 20 to 30  $\mu$  in diameter, in section semilunate, 8 to 15  $\mu$  high, 20 to 30  $\mu$  wide, containing well-developed stellate chromatophores with a large pyrenoid in the center; conceptacles very young, reproductive bodies immature.

Practically no difficulty has been encountered in referring this plant to its proper section, because both the anatomical structure of the thallus and the presence of the sexual reproductive bodies place it clearly in the Umbellatae (= Kjellman's *Dichotomaria*, Spissac). There is a problem, however, in assigning the plant to the proper species, for in his monograph Kjellman recognizes a total of six undistinguished species under "Spissae," namely, *G. obtusata* Lamouroux (*Corallina obtusata* Ell. & Sol.), *G. umbellata* Lamouroux (*Tubularia umbellata* Esper), *G. Decaisnei* Agardh, and his three newly established species, *G. tumida*, *G. insignis*, and *G. corymbifera*. In maintaining the older and proposing the new species he did not present any clear-cut specific characters and, in fact, for the old species did nothing more than merely mention the names, without giving diagnostic characteristics.

Because of their great structural similarity the Umbellatae are separated almost entirely by external differences, such as the general habit of the plants and the length and diameter of the internodes. All these external characteristics are highly subject to environmental,

tion of *Tubularia umbellata* and the plate of figures were republished in Esper's *Die Pflanzenthiere* in 1830, eighteen years after the appearance of Lamouroux's *Histoire des polypiers coralligènes flexibles vulgairement nommés zoophytes*, to which the present reference is made.

physiological, or developmental modification and, therefore, taxonomists have different opinions about the validity of the species which have been proposed. The two classical species, *G. umbellata* and *G. obtusata*, were recognized by early workers, whereas in modern publications only *G. obtusata* has been recorded.

These plants from Dalupiri, Philippine Islands (*Bartlett 15022*), agree very closely in height and in length and diameter of the internodes with Esper's illustration of *G. umbellata* from the East Indies; therefore I do not hesitate to place them with *G. umbellata*. This decision cannot be called arbitrary, for the Philippine Islands and the East Indies are within the geographical range of many species. Also, since *G. umbellata* took the lead in the first list of the *Galaxaura* species, in 1812, it might be considered the generic type ("standard species"), and therefore not to be thrown into synonymy, as was done by Børgesen.

*Type locality.* -- East Indies, according to Kjellman.

*Specimens studied.* — PHILIPPINE ISLANDS: Dalupiri Island, Babuyan Group, *Bartlett 15022*, Oct. 31–Nov. 5, 1935.

*Further distribution.* — Africa (Port Natal), Australia, West Indies, tropical Atlantic Ocean.

*Galaxaura veprecula* Kjellman. -- Pl. VI,  
Figs. 1–8; Pl. XII, Fig. 1

Kjellman, 1900, pp. 80–81, pl. 16, figs. 17–33, pl. 20, fig. 20; Yendo, 1918, p. 66; De Toni, 1924, p. 137; Tanaka, 1936, pp. 169–170, figs. 36–37, pl. 43, fig. 1; Taylor, 1945, p. 143.

Plants briefly caulescent, up to 8 cm. or more high, attached to the substratum by a broad discoid holdfast; caudex villous, upper branches widely effuse or flabelliform, distinctly flattened, branching regularly or subregularly dichotomous, sometimes subpinnate with branches unilaterally developed, thus causing the main axes to arch; internodes continuous, sometimes subarticulate and proliferous, 0.5 to 1.2 cm. long, 1 to 2 mm. in diameter, cuneate or subcuneate; thallus smooth and slightly shiny where there are no spinulose cells, but dirty-chalky and farinaceous where covered by spinulose cells; proliferations common, each encircled at the base by a tuft of extended assimilatory filaments 1.0 to 1.5 mm. long; medullary filaments 7 to 12  $\mu$  in diameter, cortical tissue tristromatic, 48 to 80  $\mu$  thick; cells of the innermost layer subglobose or compressed, often

wider than high, 20 to 30  $\mu$  tall, 35 to 45  $\mu$  broad, cells of the intermediate layer very large, subglobose, 22 to 30  $\mu$  tall, 25 to 40  $\mu$  broad, some 2- to 3-lobed, in diameter two or three times broader than tall, cells of the outermost layer (epidermis) chromatophore-bearing, in surface view angular, 16 to 28  $\mu$  in diameter, in section semilunate, 10 to 15  $\mu$  tall, 8 to 20  $\mu$  broad at the outer edge; spinulose cells occurring in patches, irregularly scattered over the surface of the thallus, commonly appearing on the thickened margins first, easily rubbed off or deciduous, clavate or elongate-spatulate, 25 to 35  $\mu$  tall, 12 to 15  $\mu$  in diameter, apex pointed or mucronate; conceptacles spherical, embedded in the thallus, each opening outward by an ostiole; female plants often with cystocarpic ostioles opening on or near the thickened margins of the thallus; carpospores ovoid or pyriform, 20 to 25  $\mu$  by 35  $\mu$  in diameter; male conceptacles more numerous, ostioles evenly scattered all over the surface of the thallus; spermatia very small, about 4  $\mu$  in diameter.

Superficially this species is almost inseparable from the nonsexual plants of section *Arboreae*, and likewise from smooth sexual *Angustifrones*, and they are often found in the same collection in herbaria, or in nature growing with the tetrasporic plants of *Arboreae*, thus indicating intimate association of the two forms, which has led to Howe's hypothesis of sexual dimorphism of these algae. However, the development of the spinulose cells on the epidermis makes the plants anatomically unique and distinguishable from the smooth species of *Angustifrones*.

In the single collection (*Bartlett 15009*) of Philippine plants thirteen of twenty-five specimens are sexual forms, with seven bearing cystocarps, two with spermatangia and four which are anatomically sexual, although no reproductive organs have been observed. The remaining twelve (*Bartlett 15009a*) are anatomically tetrasporic plants belonging to the *Arboreae*, even though tetraspores have not been found.

Although the nonsexual and the sexual plants do appear superficially identical, nevertheless, when one is familiar with these it is not difficult to distinguish them even without the aid of a low magnifier, for the thallus of the tetrasporic plant is slightly shiny, sometimes even iridescent to a slight extent, so that Børgesen described it as "often smooth and glossy, sometimes shining like mother of pearl."

*Type locality.* — Indian Ocean, near Madagascar Island.



*Type specimen.* — In Upsala herbarium under the name *G. marginata*.

*Specimens studied.* — PHILIPPINE ISLANDS: Dalupiri Island, Babuyan Group, *Bartlett 15009*, Oct. 31–Nov. 5, 1935; Batan Island, *Bartlett 15411*, July 20, 1935; COSTA RICA: Golfo Dulce, *Taylor 39-90b, 39-91b, 39-92b*, March 26, 1939; ECUADOR: Isla San Cristóbal, dredged from two to three fathoms, *Schmitt 41C-33*, Jan. 30, 1933.

*Further distribution.* — Madagascar, Formosa.

*Galaxaura ventricosa* Kjellman. — Pl. VI,  
Figs. 9–12; Pl. XII, Fig. 2

Kjellman, 1900, p. 81, pl. 16, figs. 11–16, pl. 20, fig. 24; Taylor, 1945, pp. 143–144.

Plants closely resembling *G. veprecula*; basal attachment not seen; the upper part of the branches strongly flattened, as much as 7.0 to 8.5 cm. high; texture carnose or subcoriaceous-membranous, flattened surface smooth, glabrous, even nitent, ultimate part of branches thin, membranous, or translucent; internodes continuous, rarely constricted or fractured at the base of the forkings, margin thickened, 0.5 to 1.2 cm. long, 2 to 3 mm. wide; proliferations few, when present each encircled at the base by a tuft of extended assimilatory filaments about 1 mm. long; spinulose cells of the epidermis found only on the thickened margins of the thallus; medullary filaments 8 to 15  $\mu$  in diameter; cortical tissue parenchymatous, tristromatic, 60 to 75  $\mu$  thick (excluding the spinulose cells); cells of the innermost layer strongly compressed, 20 to 36  $\mu$  high, 56 to 80  $\mu$  broad; cells of the intermediate layer variable in size and in shape, commonly 30 to 36  $\mu$  high by 35 to 44  $\mu$  broad, subglobose or some 2- or 3-lobed, with the diameter two to three times greater than the height, those below the thickened margins often subcylindrical, twice as tall as broad radially; cells of the outermost layer chromatophore-bearing, forming an epidermis, in surface view angular, 20 to 36  $\mu$  in diameter, in section semilunate, 12 to 24  $\mu$  high, 24 to 35  $\mu$  broad at the outer wall; spinulose cells columnar, fusiform, or elongate-spatulate, 32 to 40  $\mu$  high, 12 to 20  $\mu$  in diameter (commonly 16 to 18  $\mu$ ), with the apex rounded or acute, sometimes short-acuminate or slightly mucronate; extended assimilatory filaments at the base of the proliferations 12 to 16  $\mu$  in diameter, their tumid basal cells obovoid, elliptical or obpyriform,

48 to 68  $\mu$  long, 24 to 32  $\mu$  in diameter at the broadest part; shaft cells cylindrical, two to four times as long as broad, containing well-developed chromatophores; conceptacles embedded in the thallus. Plant bearing immature reproductive bodies.

Anatomically *G. ventricosa* is inseparable from *G. veprecula*, but morphologically is distinguished by its broader thallus, with a lesser development of the spinulose cells, which are limited to the margins of the thallus, and the more or less continuous branches with fewer proliferations. The thallus of *G. ventricosa* has a diameter of about three millimeters. Its internodes are nearly equal in diameter throughout, or with the upper end only slightly wider than the lower, whereas those of *G. veprecula* seldom exceed two millimeters in width and the internodes are often cuneate, with the upper end distinctly wider than the lower.

The spinulose cells of *G. veprecula* are irregularly scattered all over the surface of the thallus, but in *G. ventricosa* they are more or less localized on the thickened margins of the thallus. These spinulose cells vary somewhat in size and shape even in the same thallus, and therefore may not have any taxonomic significance at all. Nevertheless, it might be worth while to mention in this connection that in *G. ventricosa* they are generally of slightly larger diameter than in *G. veprecula*.

*Type locality*. — Near the mouth of Gabon River, Africa.

*Specimens studied*. — MEXICO: Dredged at 21.5 m. depth, near María Magdalena Island, *Taylor 39-652*, May 9, 1939.

*Further distribution*. — Near Gabon River, Africa.

*Galaxaura angustifrons* Kjellman. — Pl. VII,

Figs. 1-5; Pl. XI, Fig. 2

Kjellman, 1900, p. 82, pl. 15, figs. 11-25, pl. 20, fig. 27; Weber-van Bosse, 1921, p. 219; Taylor, 1945, p. 144.

Plants bushy, up to 9 to 10 cm. high, basal parts of the branches subterete, more or less villous, the upper ones distinctly flattened; branching regularly dichotomous, angles open, rounded or acute; segments short, commonly 5 to 7 mm. long, 1.5 to 2.0 mm. wide, continuous, margins slightly thickened; proliferations few, each encircled at the base by a tuft of extended assimilatory filaments 0.5 to 1.0 mm. long; medullary filaments 8 to 16  $\mu$  in diameter; peripheral parenchyma tristromatic, 80 to 100  $\mu$  thick; cells of the innermost layer the

largest, subglobose or angular, compressed, 30 to 50  $\mu$  high, 40 to 100  $\mu$  broad; the intermediate layer composed of subglobose or ovate cells 24 to 38  $\mu$  in diameter, and among these are lobed cells two or three times as broad as high; cells of the outermost layer constituting the epidermis, angular in surface view, 20 to 30  $\mu$  in diameter, and in section semilunate or hemispherical, 16 to 24  $\mu$  tall by 20 to 28  $\mu$  wide, containing well-developed chromatophores; extended assimilatory filaments 15  $\mu$  in diameter, slightly attenuated toward the apex; tumid basal cell obpyriform or elongate-elliptical, 48  $\mu$  long, 28 to 30  $\mu$  in diameter; shaft cells 2 or 3 times as long as thick; young filaments few-celled, composed of shorter cells whose apical cells are ovate or round; conceptacles embedded in the thallus, with ostioles opening near the thickened margins of the thallus; reproductive bodies immature.

Superficially *G. angustifrons* is practically inseparable from *G. veprecula*; in structure also the two species show close correspondence in the width and length of the internodes, the presence of the lobed cells in the intermediate layer of the cortical tissue, and in the size of the epidermal cells. However, the presence or the absence of the spinulose cells on the epidermis supplies the specific distinction, that is, *G. angustifrons* is characterized by having a glabrous thallus, whereas *G. veprecula* has a chalky or "dusty" thallus because of the development of the spinulose cells over all the surface or at least on the thickened margins. The cortical tissue of *G. angustifrons* commonly exceeds 80  $\mu$  in thickness; that of *G. veprecula* is generally less than 80  $\mu$ . In surface view the epidermal cells vary greatly in size and thus afford no distinguishing features.

*Type locality*. — Bahia, Brazil.

*Type specimen*. — In Areschoug's herbarium.

*Specimens studied*. — ECUADOR: Isla Santa Cruz, *Schmitt 81B-33*, Feb. 16, 1935.

*Further distribution*. — Brazil, Java.

***Galaxaura intermedia*, sp. nov. — Pl. VII,  
Figs. 6-10; Pl. XIII**

Taylor, 1945, pp. 144-145.

Plantae deliquescentes, arborescentes, minus quam 23 cm. altae, disco ad substratum adfixae; caudice partibusque ramorum basalibus

subteretibus, villosis; ramis sursum compressis, glabris; segmentis linearibus, continuis, 1.0–2.5 cm. longis, 1–2 mm. latis, gelatinosis, coriaceis, vix calce incrustatis, siccitate fragilibus, inconspicue transverse striatis, marginibus neque incrassatis neque involutis; filamentis medullariis 10–12  $\mu$  diametentibus, cortice parenchymatoso, 3- vel 4-stromatico, minus quam 100  $\mu$  crasso, cellulis intimis quam aliis grandioribus, ovoideis vel subrectangularibus, 28–40  $\mu$  altitudine, 50–70  $\mu$  diametro; cellulis intermediis hypodermaticisque minoribus quam intimis, subglobois, cellulis epidermatis crasse circumvallatis, angularibus, 12–20  $\mu$  diam., in sectione transversali frondis lunatis, 10–18  $\mu$  altis, 16–24  $\mu$  diam.; liberis filamentis assimilatoriis basi 16  $\mu$ , diam., ad apicem versus 18–20  $\mu$ , cellulis isodiametricis vel interdum duplo longioribus quam latoribus, absque vel cum cellulis tumidis basalibus; conceptaculis globosis, in thallo immersis, ostiis ad superficiem aperientibus. Rami carpogoniales desunt.

*Specimen typicum.* - In loco dicto "Black Beach Anchorage," Insula Sanctae Mariae, in Insulis Galapagorum, legit W. R. Taylor n. 34–213, Jan. 17–18, 1934; in herb. "Hancock Foundation," Universitatis Californiae Australis; duplum in herbario Universitatis Michiganensis.

Plant tall, as much as 23 cm. or more high, attached by a discoid holdfast, the basal part strongly caulescent, caudex villous, about 2 cm. long, 3 to 5 mm. thick at base; branches dichotomous, angles narrow, acute, slightly villous and subterete toward the base, flattened above, glabrous; segments linear or linear-cuncate, continuous, 1.0 to 2.5 cm. long, 1 to 2 mm. wide, subcoriaceous or carnose-membranous, more gelatinous and less calcified than other known species, brittle when dried; inconspicuously striated, margin neither thickened nor involute; thallus attenuate toward the apex, less than about 1 mm. wide; medullary filaments subequal, 10 to 12  $\mu$  in diameter; cortical tissue strongly parenchymatous, 3- to 4-stromatic, about 100  $\mu$  thick; cells of the innermost layer the largest, subglobose, rectangular, 28 to 40  $\mu$  tall, 50 to 70  $\mu$  in diameter, generally wider than tall, cells of the intermediate layers more or less globose, ovate, larger in 1-layered parts than in 2-layered; lobed cells not seen; the outermost layer or epidermis composed of thick-walled cells, angular in surface view, 12 to 20  $\mu$  in diameter, in sectional view semilunate, 10 to 18  $\mu$  tall, 16 to 24  $\mu$  wide; extended assimilatory filaments cylindrical, slightly contracted toward the base, with or without tumid

basal cells; shaft cells 16 to 20  $\mu$  in diameter, one to two times as long as wide; conceptacles embedded in the thallus, with ostioles opening on the surface; reproductive bodies immature.

The species is characterized by having a smooth, glabrous thallus whose epidermal cells are free from the development of spinulose cells — a characteristic that is considered by Kjellman a sufficient basis for the separation of sections *Angustifrones* (his *Laevivrons*) and *Vepraculae*. It may further be distinguished by the very thick outer wall of the epidermal cells, containing a high percentage of gelatinous substance which absorbs moisture readily in damp weather.

The section *Angustifrones* has hitherto been composed of only two species, as first proposed by Kjellman. The first species, *G. magna*, is based on plants from Cape Agulhas, Africa, and the other, *G. angustifrons*, on plants from Bahia, Brazil. In the section the Ecuadorian plant seems to have a position intermediate between its two predecessors, for it possesses some characteristics in common with *G. magna* (a species that has been omitted from the present treatment because of lack of material), and some with *G. angustifrons*.

The new species agrees with the description of *G. magna* in almost every respect except for its much narrower branches, which, in fact, are the narrowest in all the three species of the *Angustifrones* so far proposed. The thick gelatinous cell wall of *G. intermedia* expands considerably when it comes in contact with moisture. Thus in damp weather, when the humidity of the air is high, the specimen can absorb enough moisture to loosen itself from the herbarium sheet. On the contrary, under dry conditions the thallus becomes rather brittle, like that of *Chondrus* or *Laminaria*. Its low content of lime is shown by the release of few bubbles in decalcification.

Among the duplicates under this number (*Taylor 34-213*) I have recently detected one tetrasporic specimen which is identical in structure with the tetrasporic plants (*Taylor 34-164*) of Santa Maria Island, Galápagos, that I have assigned to *G. spathulata* Kjellm. (Chou 1945, p. 53). Because of the similarity in size of these two forms a suggestion was made in connection with the discussion of *G. spathulata* that a sexual plant which is likewise tall and arborescent might represent the sexual phase of *G. spathulata*. The finding of this tetrasporic plant among the sexual forms further strengthens my presumption that those nonsexual plants treated under the name *G. spathulata* and the sexual plants described under the present new name *G. intermedia*

are representatives of the two phases of one life history. More collecting and study will be necessary to validate this hypothesis.

*Specimens studied.* — ECUADOR: Black Beach Anchorage, Isla Santa Maria, Galápagos Islands, *Taylor 34-213* (TYPE), Jan. 17-18, 1934.

*Further distribution.* — So far as known, endemic to the Galápagos Islands in the eastern Pacific.

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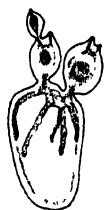
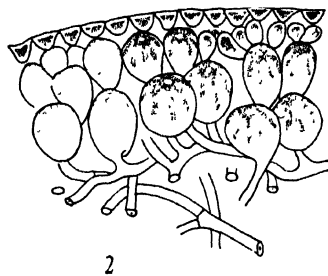
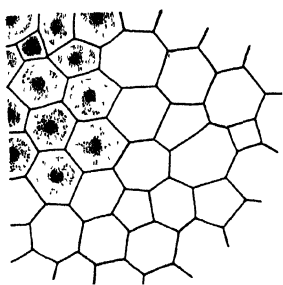
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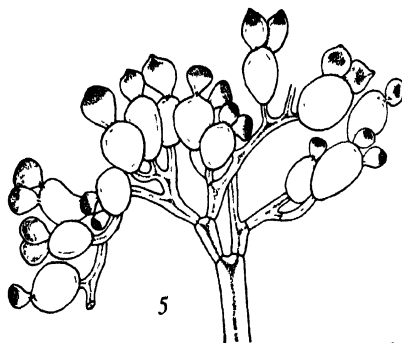
## EXPLANATION OF PLATE I

*Galaxaura cylindrica*

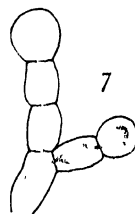
- FIG. 1. Surface view of epidermis.  $\times 340$
- FIG. 2. Section of portion of thallus.  $\times 340$
- FIGS. 3-4. Hypodermal and cortical cells.  $\times 610$
- FIGS. 5-6. Medullary filaments bearing cortical cells.  $\times 340$
- FIGS. 7-8. Short free ends of filaments at fractured nodes.  $\times 340$
- FIG. 9. Spermatangia with spermatia.  $\times 610$
- FIG. 10. Young branched filaments inside spermatangium.  $\times 610$
- FIG. 11. Spermatangial branches, showing some spermatangia, with secondary or tertiary spermatangia developed within old walls.  $\times 610$
- FIG. 12. Young spermatangia and young branching filament.  $\times 610$



3



5



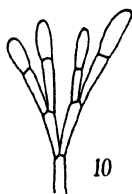
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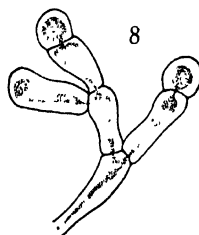
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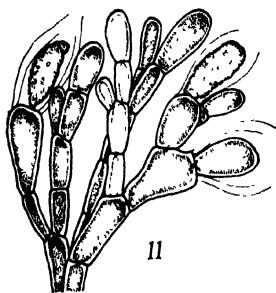
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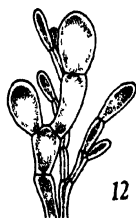
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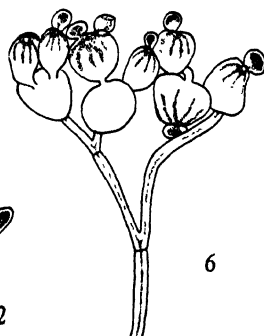
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11



12



6



## EXPLANATION OF PLATE II

### *Galaxaura oblongata*

FIG. 1. Epidermis, surface view.  $\times 340$

FIGS. 2-4. Medullary filaments bearing cortical cells  $\times 340$

FIG. 5. Habit of conceptacle removed from thallus.  $\times 80$

FIG. 6. Cluster of branching filaments inside the conceptacle.  $\times 310$

FIGS. 7-9. Sporogenous filaments with carposporangia.  $\times 340$

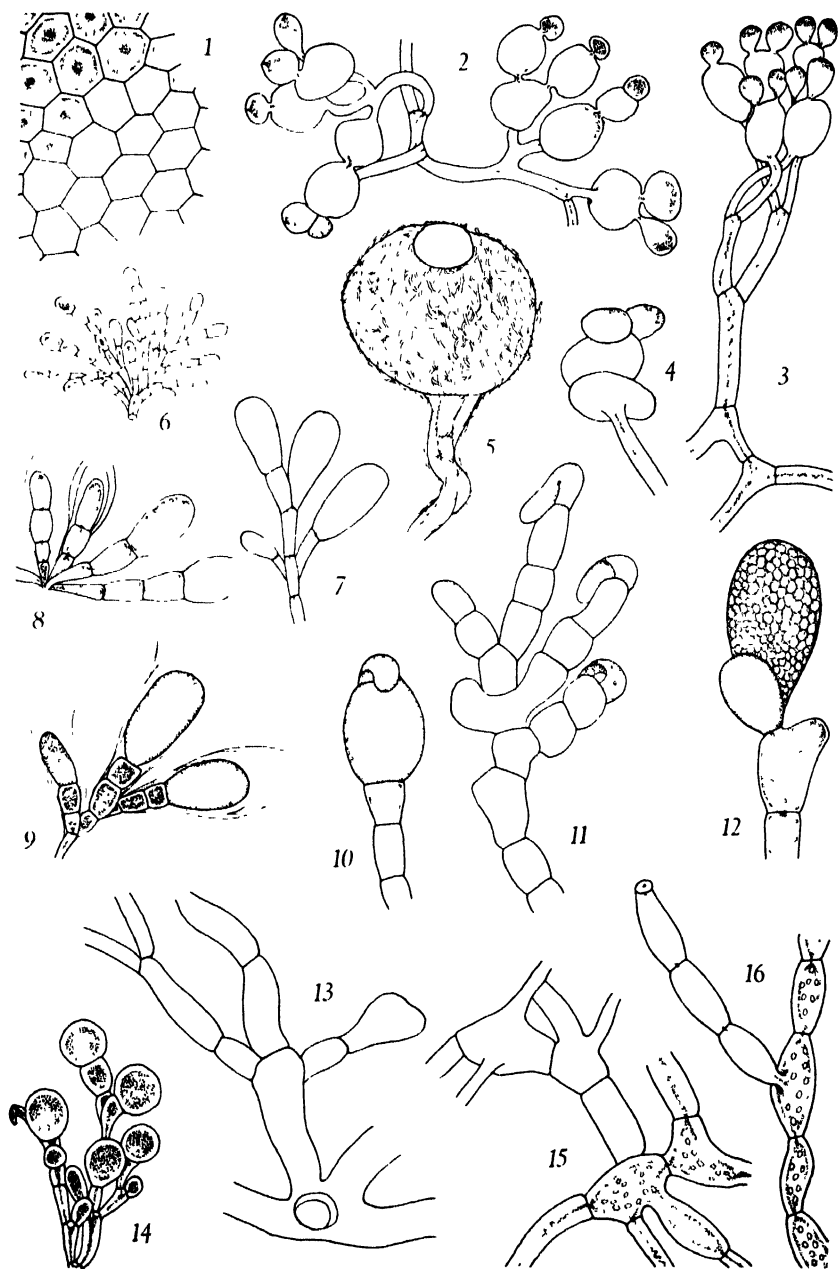
FIGS. 10-12. Hypertrophied carposporangial filaments containing starch grains.  
 $\times 340$

FIG. 13. Spermatangial filaments showing whorled branching.  $\times 310$

FIG. 14. Ultimate spermatangial filaments bearing spermatangia.  $\times 610$

FIG. 15. Medullary filaments with much enlarged cells containing starch grains  
at base of conceptacle.  $\times 340$

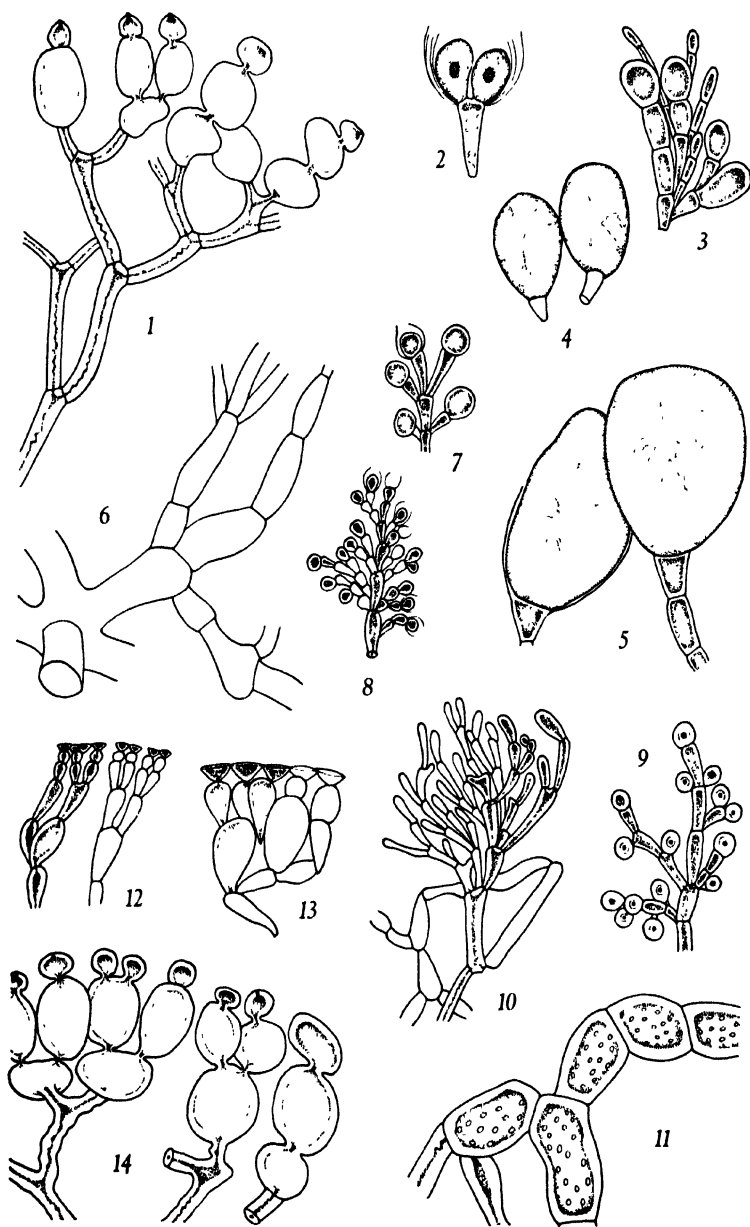
FIG. 16. Gonimoblast filaments at base of conceptacle.  $\times 340$



## EXPLANATION OF PLATE III

### *Galaxaura oblongata*

- FIGS. 1, 14. Medullary filaments bearing cortical cells.  $\times 340$
- FIG. 2. Regeneration of carposporangium.  $\times 340$
- FIG. 3. Carposporangial filaments with young carposporangia.  $\times 340$
- FIGS. 4-5. Carpospores showing variation in size.  $\times 340$
- FIG. 6. Base of spermatangial filament with whorled branching.  $\times 340$
- FIG. 7. Ultimate spermatangial filaments with spermatangia.  $\times 610$
- FIG. 8. Ultimate spermatangial filaments with spermatangia.  $\times 340$
- FIG. 9. Ultimate spermatangial filaments with young spermatangia.  $\times 610$
- FIG. 10. Ultimate spermatangial filaments before spermatia are differentiated.  
 $\times 340$
- FIG. 11. Gonimoblast filaments at base of female conceptacle.  $\times 340$
- FIG. 12. Young vegetative filaments of apex of thallus.  $\times 340$
- FIG. 13. Slightly older filaments below apex of thallus, showing development of cortical cells.  $\times 340$



## EXPLANATION OF PLATE IV

### *Galaxaura squalida*

FIGS. 1-2. Section of portion of thallus, showing cortical tissue and extended assimilatory filaments.  $\times 225$

FIG. 3. Epidermal cells, surface view.  $\times 225$

FIG. 4. Surface of epidermis, showing circular cells bearing extended assimilatory filaments.  $\times 225$

FIG. 5. Cystocarp (pericarp) longitudinal section  $\times 225$

FIGS. 6-7. Gonimoblast filaments with carposporangial branches bearing carposporangia at the distal ends.  $\times 225$

FIGS. 8-9. Carpogonial branches bearing carpogonia.  $\times 225$

FIG. 10. Extended assimilator, showing branching  $\times 225$

FIG. 11. Basal and terminal parts of extended assimilatory filament.  $\times 225$

### *Galaxaura rugosa*

FIG. 12. Epidermis surface view, showing angular epidermal cells and circular cells bearing extended assimilatory filaments.  $\times 225$

FIG. 13. Section of portion of thallus.  $\times 225$

### *Galaxaura glabruscula*

FIG. 15. Epidermis, surface view.  $\times 225$

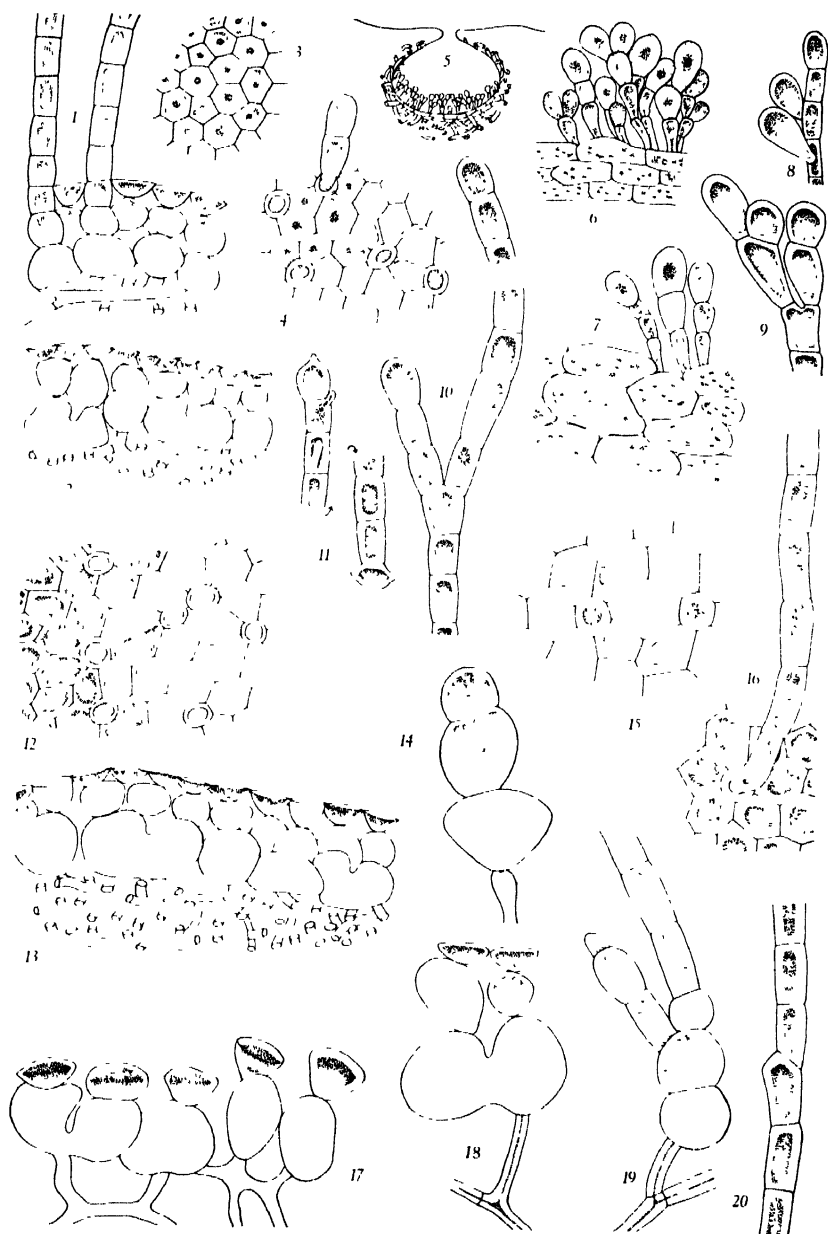
FIG. 16. Epidermis surface view, showing those circular cells among angular ones bearing extended assimilatory filaments.  $\times 225$

FIG. 17. Section of portion of thallus.  $\times 225$

FIGS. 14, 18. Cortical cells in relation to medullary filaments.  $\times 225$

FIG. 19. Extended assimilatory filaments in relation to cortical cells and medullary filaments.  $\times 225$

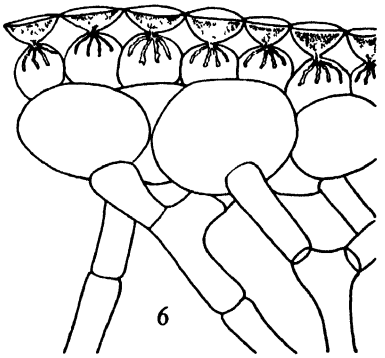
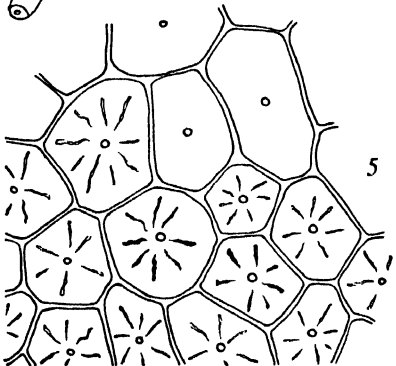
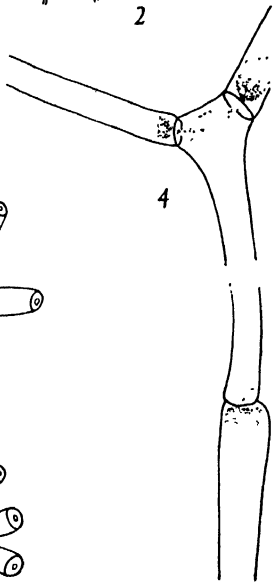
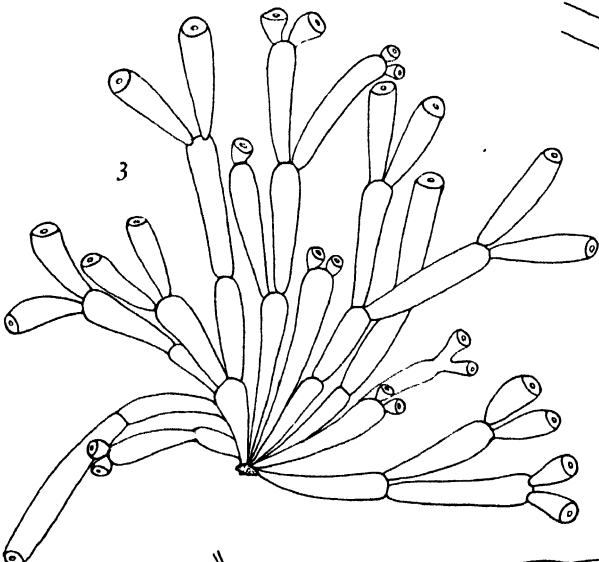
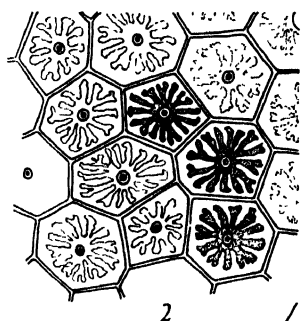
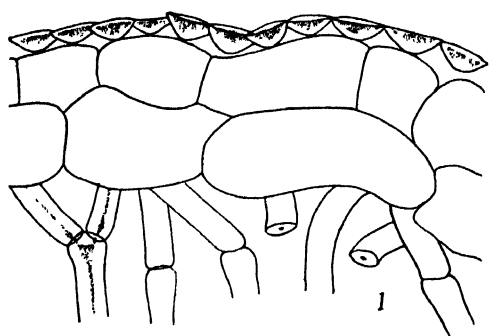
FIG. 20. Upper portion of extended assimilator, showing possible branching.  $\times 225$



## EXPLANATION OF PLATE V

### *Galaxaura umbellata*

- FIG. 1. Section of portion of older thallus.  $\times 340$   
FIG. 2. Surface view of epidermis.  $\times 340$   
FIG. 3. Habit of part of plant.  $\times 1$   
FIG. 4. Medullary filament.  $\times 340$   
FIG. 5. Surface view of hypodermal layer of cells (intermediate layer of cortex), showing stellate chromatophores.  $\times 340$   
FIG. 6. Section of portion of young thallus.  $\times 340$





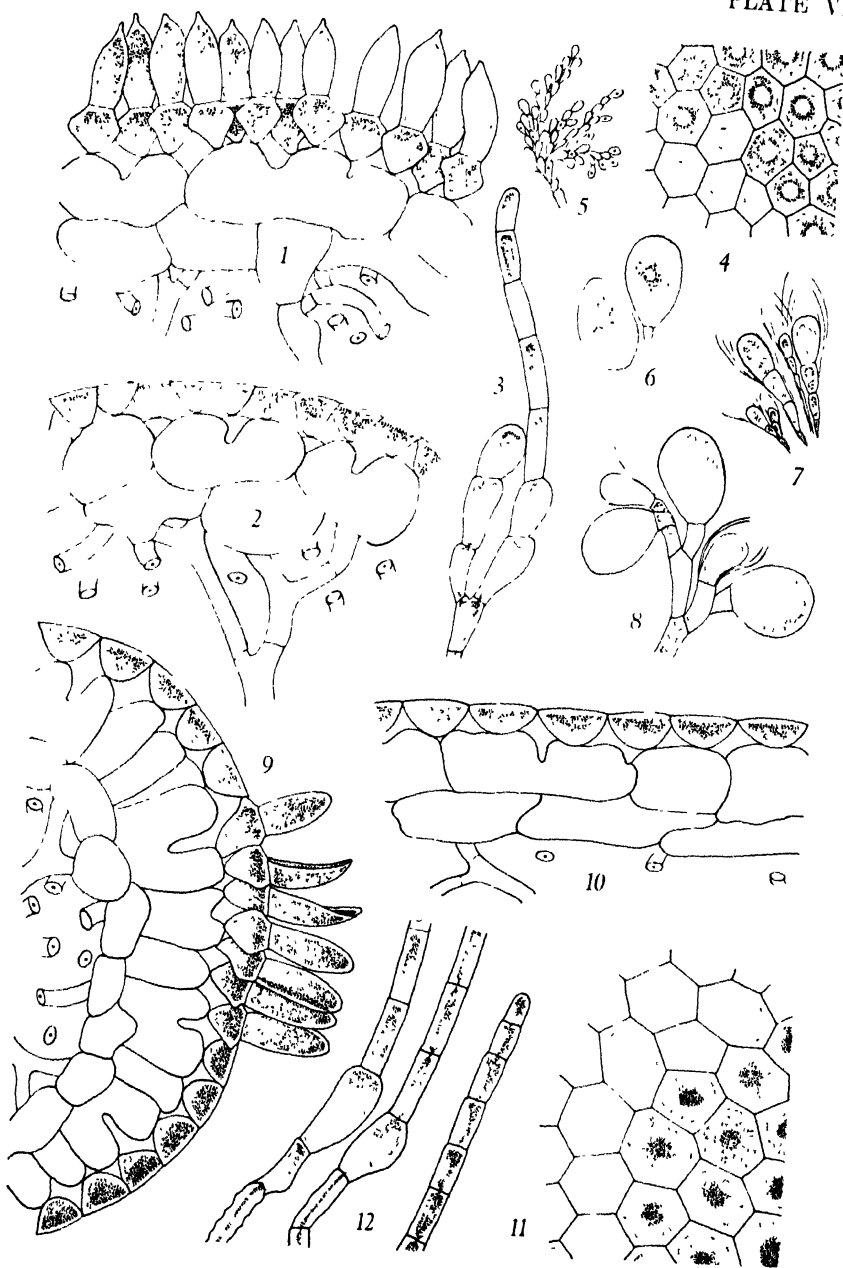
## EXPLANATION OF PLATE VI

### *Galaxaura reprecula*

- FIG. 1. Section of portion of thallus, showing epidermal cells bearing spinulose cells.  $\times 340$
- FIG. 2. Section of portion of thallus without spinulose cells.  $\times 340$
- FIG. 3. Extended assimilatory filament on the base of proliferation.  $\times 195$
- FIG. 4. Surface view of epidermis.  $\times 340$
- FIG. 5. Antheridial branch bearing spermatangia  $\times 340$
- FIG. 6. Two carposporangia.  $\times 340$
- FIG. 7. Young secondary carposporangia with sheaths of old carposporangial walls.  $\times 340$
- FIG. 8. Older stage of carposporangial branch with carposporangia.  $\times 340$

### *Galaxaura ventricosa*

- FIG. 9. Transverse section of thickened margin of thallus.  $\times 195$
- FIG. 10. Section of portion of flattened side of thallus.  $\times 340$
- FIG. 11. Surface view of epidermis.  $\times 340$
- FIG. 12. Extended assimilatory filaments at the base of proliferations.  $\times 195$



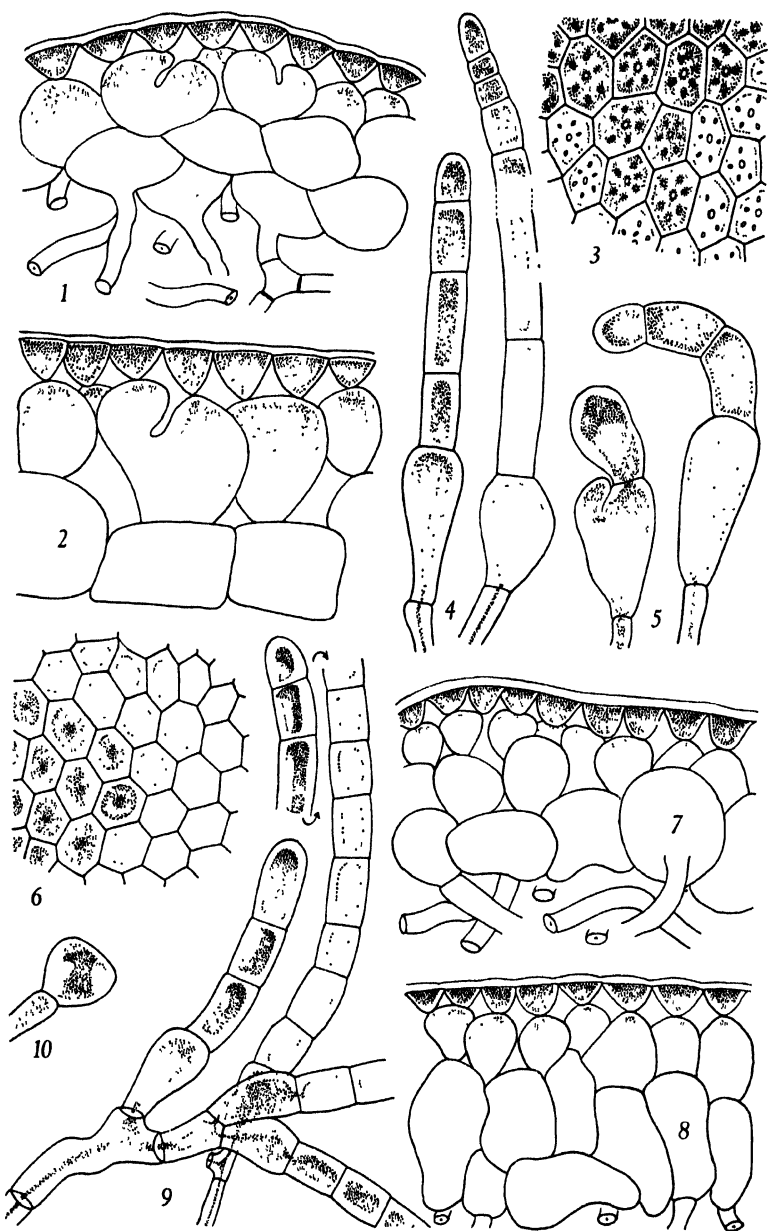
## EXPLANATION OF PLATE VII

### *Galaxaura angustifrons*

- FIGS. 1-2. Section of portion of thallus.  $\times 340$   
FIG. 3. Surface view of epidermis.  $\times 340$   
FIG. 4. Extended assimilatory filaments.  $\times 340$   
FIG. 5. Young extended assimilatory filaments.  $\times 340$

### *Galaxaura intermedia*, sp. nov.

- FIG. 6. Surface view of epidermis.  $\times 340$   
FIG. 7. Section of portion of thallus.  $\times 340$   
FIG. 8. Section of portion of thallus at the thickened margin.  $\times 340$   
FIG. 9. Extended assimilatory filaments.  $\times 340$   
FIG. 10. Young developing extended assimilatory filament.  $\times 340$



## EXPLANATION OF PLATE VIII

FIG. 1. *Galaxaura cylindrica*; *Bartlett 14981*, Dalupiri Island, Babuyan Group,  
P. I.  $\times 1$

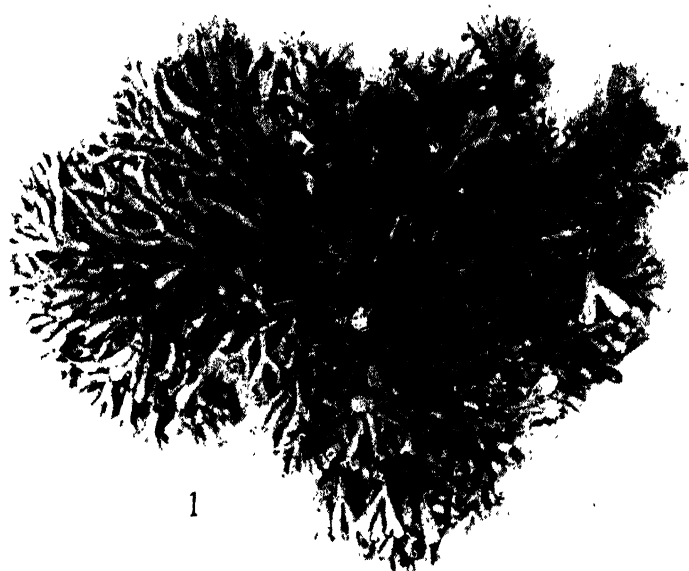
FIG. 2. *Galaxaura squalida*, *Villaflora*s 6, 8, Mindoro Province. P. I.  $\times 1.1$



## EXPLANATION OF PLATE IX

FIG. 1. *Galaxaura oblongata*, male plant; *Bartlett 16185*, Liloan Beach, Cebu Island, P. I.  $\times 1.1$

FIG. 2. *Galaxaura oblongata*, female plant; *Bartlett 14980*, Dalupiri Island, Babuyan Group, P. I.  $\times 1$





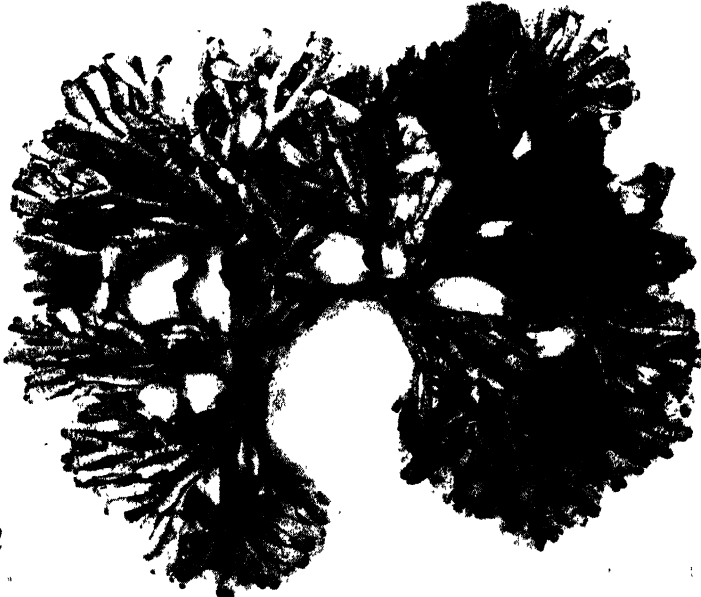
## EXPLANATION OF PLATE X

FIG. 1. *Galaxaura glabriuscula*: *Kostermans 254*, Eiland Kêlapa, Duizend-eilanden, Java  $\times 1.2$

FIG. 2. *Galaxaura rugosa*, *Bartlett 15410*, Batan Island, P. I.  $\times 1.3$



1.

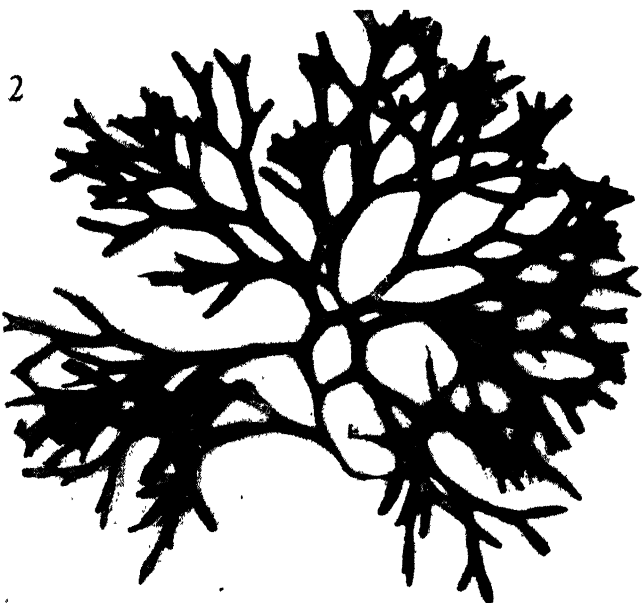


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## EXPLANATION OF PLATE XI

FIG. 1. *Galaxaura umbellata*; Bartlett 15022, Dalupiri Island, Babuyan Group,  
P. I.  $\times 1.25$

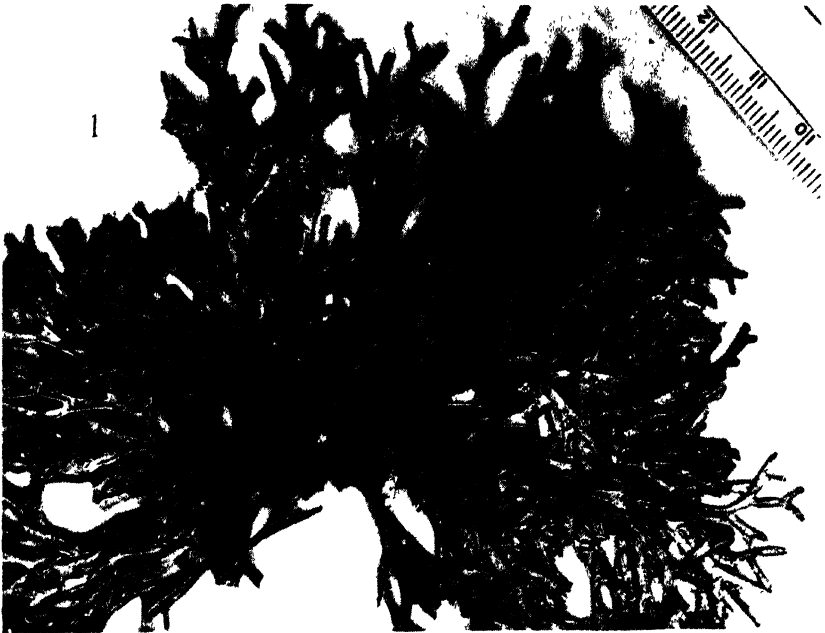
FIG. 2. *Galaxaura angustifrons*; Taylor 81-33, Isla Santa Cruz, Ecuador.  
 $\times 1.5$



## EXPLANATION OF PLATE XII

FIG. 1. *Galaxaura veprecula*. Bartlett 15009b, Dalupiri Island, Babuyan Group,  
P. I.  $\times 1$

FIG. 2. *Galaxaura ventricosa*. Taylor 39-652, Isla María Magdalena, Mexico.  
 $\times 1$



### EXPLANATION OF PLATE XIII

*Galaxaura intermedia* Chou, sp. nov.; *Taylor 34-213* (TYPE), Isla Santa María,  
Galápagos Islands, Ecuador.  $\times 0.75$







# OBSERVATIONS ON THE HABITS OF SOME OF THE NATIVE PLANTS OF KALA- MAZOO COUNTY, MICHIGAN

CLARENCE R. HANES

THE observations on the habits of the plants reviewed in this paper were carried on from 1934 through 1944 by Mrs. Florence N. Hanes and the writer. In 1944 especially we made an intensive exploration in several of the lakes of the county. The plants studied are mainly aquatic species — those growing in a few inches or several feet of water or on the shores of ponds and lakes or on the beds of the ponds during the seasons when they have become partly or completely dry.

Many of the water plants have various means of reproduction other than by seed. They have different forms of tubers or root-stalks, as do some of the genus *Potamogeton*. They may be broken up by wind or dislodged by fishermen, and these separated parts may take root and make new plants. *Cabomba caroliniana* is an example. *Myriophyllum heterophyllum* sends out new shoots from the blossom spike, and others of the *Myriophylla* produce winter buds along the stems. Compact or loose leafy buds of some of the *Utriculariae* pass the winter on the bottom of pond or lake.

Whether a plant should be classed as "rare," "infrequent," or "common" in a given territory should depend upon how thoroughly the territory has been botanized throughout several growing seasons. Also, before a verdict is given one ought to be familiar with the same plant both when it is in the flowering state and when merely the sterile form is to be seen. Some of the water plants blossom only occasionally, and even when they do the inflorescence may be so inconspicuous that it can be overlooked.

In 1941 we found many specimens of *Potamogeton Robbinsii* Oakes on the shore or in the shallow water of Austin Lake. For a number of years prior to this date we had visited the lake but had never seen any of this pondweed. During 1942, 1943, and 1944 there was no

reappearance, at least near the shores. Apparently *P. Robbinsii* has at intervals its seasons of abundance.

*Scheuchzeria palustris* L. var. *americana* Fern. is a plant of sphagnum bogs. The only station known to us in Kalamazoo County is in an extensive bog in Section 28, Portage Township. Here on June 27, 1940, standing in one place we were able to count 100 of these plants and in another place 125 of them. All were in fruit. On June 29, 1941, after an extended search over the same ground where so many fruiting plants had been found the previous year, only one in fruit was discovered. This did not mean that there were none of these plants present, since we saw plenty of their grasslike leaves. The leaves can be mistaken for those of grasses, sedges, or rushes, but close inspection will reveal the tiny opening at their tips which is a diagnostic character of the species. The apparent rarity of the plant may therefore be due partly to its capricious fruiting habits.

*Scirpus subterminalis* Torr. is considered by some botanists to be of infrequent occurrence. Our first introduction to the species was through the collection of a mass of plant refuse dislodged by wind and deposited on the shore of Pawpaw Lake. When this was studied at home, specimens of *S. subterminalis* were found mingled with other aquatic flora. The following year (1939) beds of this plant were seen at Pawpaw Lake in about two feet of water. They extended a few yards offshore, for a distance of several rods. Only a portion of the beds sent up fruiting culms, the rest consisting of plants with the fine sterile leaves. Later this species was found in Barton, Stony, and Thrall lakes. During 1944, when a survey was made in several of our county lakes, beds of *S. subterminalis* were discovered in Blue, Eagle, Mud (Portage Township), Pickerel, and Weeds lakes. In Weeds Lake and in parts of Eagle Lake the beds were extensive and showed signs of fruiting, but in the other three merely the sterile leaves were seen. These leaves, when covered with a marly deposit, are rather drab and may be thought to be filaments of algae. They are cellular and channeled and are not often more than four to six decimeters in length. Sometimes they grow at depths of five feet. The fertile culms, which are larger, apparently do not always produce spikelets, since we have examined many before getting one with the inconspicuous fruiting part.

*Scirpus fluviatilis* (Torr.) Gray is frequent in the western half of the county on lake and pond borders and in the shallow water in such

places. When the water level becomes too high, this sedge may entirely disappear until conditions again become favorable. At most of the stations known to us, however, it is found in the same places year after year. When in anthesis it is a very noticeable plant, with many spreading rays to each showy umbel, but in our county fruiting is erratic or almost absent over a period of years. We have never seen a blossom among several stands of these plants, although the culms have always been robust. We saw more fruiting in 1938 than at any time before or since. The beds at Twin Lakes, Alamo Township, appear to be exceptional in that they were in flower in 1941 and again in 1942.

*Eleocharis Robbinsii* Oakes is reported in Deam's *Flora of Indiana*<sup>1</sup> from only two counties, which are in the northeastern part of that state. Until recently it was considered rare in Michigan also, but field work during the past decade has shown new stations until now we have reports from Allegan, Cass, Kalamazoo, Kent, Presque Isle, and St. Joseph counties in the Lower Peninsula and from Alger County in the Upper Peninsula.

In Kalamazoo County we have found it in small numbers at Austin, Pickerel, and Stony lakes and in abundance at Eagle, Pine Island, and Thrall lakes. In 1941 a swamp east of Gourdneck Lake, which became dry during that year, had its borders covered with this sedge. In swamps southwest of West Lake it was also extremely common. In 1944 at Weeds Lake in Texas Township this species was found on the shores and in shallow water. On floating islands in the lake pure stands of it made yellowish-green carpets.

This sedge grows in the shallower parts of ponds and lakes, but thrives best on soil from which the water has recently receded. It has slender rootstalks, and some new plants are developed from these as the colonies are very dense. It is apparently shy about fruiting during most seasons. The spikelet is quite inconspicuous in flower, and in fruit it has a ragged appearance, as if it had been injured or gnawed. Our own experience shows that it can easily be overlooked. For several years prior to 1938, when we discovered our first specimens, we had waded in the shallow water of a pond where hundreds of this species normally grow without becoming aware of their importance.

Those familiar with *Eleocharis rostellata* Torr. know that many of

<sup>1</sup> Deam, C. C., *Flora of Indiana* (Indianapolis, 1940), p. 200.

the sterile culms take root at the tips. Walking through a grassy swamp where this sedge grows, one is made aware of its presence by hearing the steady snapping as the culms fastened at both ends are broken loose.

Unlike *Eleocharis rostellata*, *E. melanocarpa* Torr. roots mainly at the tips of the fertile culms, or at least its first rooting occurs at the base of the spikelets, and under the right conditions it takes place soon after the achenes are ripe. As many as ten plants may come from a like number of tips. This early proliferation usually begins the last of July or the first of August. When these newer plants are well grown, some of them may produce others from what might now be considered sterile culms. This is noticeable in the middle of September, at which time the parent plant and its first and second progeny are all tied together.

We have specimens with the small roots growing from the base of the spikelet before the spikelet has begun to shed its scales and achenes. We have observed this habit of *Eleocharis melanocarpa* at Eagle and Pretty lakes in Texas Township, especially in plants growing in the sand near or on the margins of the lakes. Here the plants have not been crowded by other vegetation. At Austin Lake, where the culms are more densely tufted and grow in less sandy soil and are associated with a ranker floral growth, this species is less proliferous. Whatever young plants are produced do not begin to develop before September. In 1944 late development was also observed at Eagle Lake in situations where the conditions were similar to those at Austin Lake.

*Rhynchospora macrostachya* Torr., an Atlantic Coastal Plain species, is frequent in the southwestern part of the county. Acres of it have been seen in shallow water at Crooked Lake. When the "Island" pond west of the village of Schoolcraft is nearly dry, a good stand appears, but for the past few years, with water four or five feet deep, no plants have been observed. Elsewhere periods of high water have reduced the number of this species to a minimum.

*Rhynchospora fusca* (L.) Ait. f. has been discovered<sup>1</sup> at only one site in Kalamazoo County. This sedge is mostly near the Atlantic Coastal Plain. According to a map showing the distribution of *R. fusca* in the United States and Canada,<sup>2</sup> our station is the farthest south of

<sup>1</sup> Gale, Shirley, "Rhynchospora, Section Eurhynchospora, in Canada, the United States and the West Indies," *Rhodora*, 46: 132. 1944.

those in the interior of the country. It is in a pond or marsh southwest of West Lake. During 1938-41 there were scattered masses of this stoloniferous plant growing in the peat moss. Later, with water covering the site to a depth of two to three feet, no traces were seen of it until the fall of 1944. By that time the pond had dried away, and once more one could walk over the ground. Plants again formed carpets of rusty hue, but evaporation had occurred so late that only a few achenes were produced. Another dry season will, no doubt, show an abundance of fruiting plants. The growth now appears to occupy the same relative positions that it did during 1938-41. Apparently, while the water had covered the area, no new beds had formed nearer the shores.

*Lemna valdiviana* Philippi is a Lemna about which we know very little. It is included in this paper partly because our discovery of it is a new record for the state. Professor M. L. Fernald, who confirmed our determination, knew of no other report from Michigan. We found it on November 24, 1943, in shallow water near Fox and Beers' mill in Section 26, Prairie Ronde Township. A dish of aquatic plant material was collected; when we examined it at home we discovered many specimens of *L. valdiviana* associated with *L. minor*, *L. trisulca*, and *Wolffia columbiana*. Again, on November 4, 1944, we gathered material from the same pond, but were able to distinguish only a very few plants of this species in it.

*Myriophyllum tenellum* Bigel., unlike the other Myriophylla, is almost leafless. It is a small plant with a scape usually less than one millimeter in diameter and about one decimeter high. Horizontal creeping rootstalks buried two centimeters or more in the sand may send up as many as ten plants. Half of these may be fertile. All that we have observed have been in very shallow water adjacent to the shore. Often some of the plants are on the shore where wave action can moisten them.

We first collected specimens on the east and south shores of Eagle Lake in September, 1934, and August, 1935. Later we found masses several yards in extent at Pretty Lake. In 1936 plants were abundant at these two lakes, but during the seasons from 1937 through 1940, when the water in the lakes was high, none were seen. In 1941 it reappeared in small numbers, but in 1943 and 1944 it had again vanished. It was during these years that the lakes extended their shorelines several rods inland.

Some texts state that this species is usually submersed. At least when in anthesis the spikelet must be emersed. Whether plants can persist in more than a foot of water for long periods without blossoming is unknown to us. Then they would be difficult to locate, since they might not be matted in beds, as they are when the water is very shallow.

*Myriophyllum tenellum* is not at all common in the state. At one time it was considered very rare, but collections in recent years by the Institute for Fisheries Research have shown a wider distribution, especially in the Upper Peninsula and from Kent County northward in the Lower Peninsula. Records from ten Michigan counties, sent to us by Mrs. Betty R. Clarke from the University Herbarium, place our stations at Eagle and Pretty lakes farther south than any others yet reported.

On August 5, 1936, we made our first discovery of *Lindernia anagallidea* (Michx.) Pennell (*Ilysanthes anagallidea* of Gray's *Manual*, Seventh Edition). This was in a pond a short distance east of Gourdneck Lake. The pond is alternately almost dry or filled with water to varying depths. The year 1936 was at the end of several dry years. The plants were in mud and lay spread out, so that the largest occupied a space of a square foot. There were one rather heavy root and a few smaller ones to each plant. The several main stems had branches which, in turn, bore small branchlets. The main fruiting branches produced about 100 flowers each and the whole plant at least 600.

On August 19, 1937, the pond had begun to fill up. Where the spreading plants had been discovered the previous year a few were located in six or seven inches of water. These had many fibrous roots, but not more than 8 flowers to a stem and fewer than 25 to a plant. The stems were erect and not branched. During 1941 the water receded again, but no plants were seen. For the three years 1942 through 1944 the pond has had several feet of water, so that there has been little opportunity to rediscover this species. We have collected it only at this station. It appears to be rare in our state.

During periods of high water we have found only a small percentage of the plants of *Utricularia resupinata* B. D. Greene that we have seen after several dry seasons. The specific name of *Lycopodium inundatum* L. shows that this plant must be sometimes expected to be under water. At the few stations where we have been fortunate to

find it, water has completely covered it since 1942. On the other hand, high-water levels bring to life again plants that apparently have been nonexistent for many years. Their habitats may become so desiccated that they or their seed remain dormant. *Scirpus Smithii* Gray has been discovered where it was not known to exist, and cattails — both the broad-leaved and the narrow-leaved species — were seen in 1944 in a field that had been continually cropped for more than a decade.

SCHOOLCRAFT, MICHIGAN





# THE BRYOPHYTE FLORA OF MICHIGAN \*

WILLIAM CAMPBELL STEERE †

THE bryophyte flora of Michigan has been so intensively collected and studied during the last thirty-five years that it has come to be among the largest and best known in the United States. It is now difficult to realize or even to believe that Michigan bryology was an almost totally unknown phase of botany near the turn of the century.

The exhaustive studies in Ohio by Sullivant, Lesquereux, and other early bryologists apparently led them to the erroneous assumption that the bryophyte floras of Michigan and Ohio were more or less identical. Consequently, they encouraged their botanical correspondents to collect bryophytes in more distant states, with the result that, although specimens from Wisconsin, Minnesota, and Illinois are frequently cited in such standard earlier works as Lesquereux's "Supplement" to Sullivant's *Icones Muscorum* (1874), Lesquereux and James' *Manual of the Mosses of North America* (1884), and Underwood's *Descriptive Catalogue of the North American Hepaticae, North of Mexico* (1884), Michigan is never mentioned.

It is surprising that many of the early publications dealing with Michigan bryophytes are based on collections made in the more inaccessible parts of the state. Sprague's report (1858) of *Neckera pennata*, collected on Keweenaw Point by Dr. Thomas Kneeland, is apparently the first published record of a Michigan moss, and Austin's description (1872) of a new species, *Jungermannia Gillmani*, marks the first report of a Michigan hepatic. This species, now known as *Leiocolea Gillmani* (Evans and Nichols, 1935), was first collected on Au Train Island, in Alger County, by Henry Gillman, who later re-

\* Contribution from the Department of Botany, the Herbarium, and the Biological Station of the University of Michigan.

† I wish to acknowledge here my obligation to several grants-in-aid from the Faculty Research Fund and from the Horace H. Rackham School of Graduate Studies of the University of Michigan, which have made possible much of my field work outlined in this paper.

ported *Preissia quadrata* from Huron County in the "Thumb" district and from several other localities (1876).

The reports on Michigan bryophytes fall clearly into two general classes: (1) casual or incidental mention of a few species in floristic or ecological researches; and (2) lists of species based on the special study of a specific collection or region. The first class is especially well illustrated by the several publications on the vegetation of northern Michigan by E. J. Hill (1885, 1886, 1900, 1902, 1905, 1909). A search of his articles has turned up references to *Dicranum scoparium*, *D. undulatum*, "*Trematodon longicollis*," "*Rhabdoweisia fujax*," *Mnium marginatum*, and *Cratoneuron filicinum* from the Menominee iron region (1885); *Marchantia polymorpha* from the White Lake region, Muskegon County (1900); *Encalypta procera*, *Distichium capillaceum*, and *Myurella Careyana* from Presque Isle, Marquette County (1905); and *Dicranum fuscescens* (1886), *Amblystegium noterophilum* (1909), and *Fissidens grandifrons* (1902, 1909) from Boyne Falls, Charlevoix County. *Mnium rostratum* and *Polytrichum strictum* were reported anonymously in 1900 [Smith] from collections made by C. K. Dodge. In 1904 F. P. Daniels referred to *Marchantia polymorpha*, *Conocephalum conicum*, *Preissia quadrata*, *Riccia fluitans*, and *Ricciocarpus natans* in a paper on the flora of Manistee, and to *Marchantia polymorpha*, *Riccia fluitans*, and *Ricciocarpus natans* in an ecological study of the vicinity of Sturgis, in St. Joseph County. *Ditrichum giganteum*, first collected in the Yukon by Williams, was ascribed to Michigan by Mrs. Britton (1913a), but the specimen referred to cannot be found at the New York Botanical Garden, and the species does not seem to have been collected again in the state. The Michigan report of *Blindia acuta* (Britton, 1913b), however, has been confirmed. In a list of plants inhabiting ravines near Adrian (Lenawee County) F. L. Stearns (1905) tabulated *Mnium*, *Funaria*, *Aulacomnium*, *Bartramia*, and *Conocephalum* as "characteristic mesophytic herbs." Since there is no ambiguity concerning the species meant (cf. Steere, 1933b), we may include these reports without question as *Mnium cuspidatum*, *Funaria hygrometrica*, *Aulacomnium heterostichum*, *Bartramia pomiformis*, and *Conocephalum conicum*. The last incidental reference to be included here is the mention by Gates (1912) of *Marchantia polymorpha* in an ecological study of Cheboygan County.

The more strictly bryological researches making up the second

category may be subdivided on a geographical basis, depending on whether they concern themselves with the Upper or the Lower Peninsula of Michigan.

#### I. THE LOWER PENINSULA

The first substantial published list of Michigan mosses was based on a collection made during October and November of 1891 by A. Purpus, in the vicinity of Clarklake (Jackson County), in the southern part of the Lower Peninsula. Dr. Julius Röhl, a well-known German bryologist, made a botanical collecting trip across the United States in 1888. He inspired many of his countrymen here to collect for him, which explains why the Purpus collection went to Germany for study. In a report covering several collections made in a number of states Röhl (1897) listed 70 species of mosses and 9 species of Sphagnum collected by Purpus at Clarklake, as well as 3 species of Sphagnum sent from Opechee (Keweenaw County) by Bollmann, another correspondent. Unfortunately, Röhl submitted many of his specimens for identification to N. C. Kindberg, a notoriously undependable bryologist, who usually found it much easier to manufacture new species than to identify specimens with known species (Steere, 1939b). In Röhl's list we find reports of several species whose existence in southern Michigan is highly improbable, especially *Entodon orthocarpus* (LaPyl.) Lindb. (as *Cylindrothecium concinnum* Sch.) and *Brotherella Roellii* (Ren. & Card.) Fleisch. (as *Raphidostegium*). I am quite certain that the report of the *Entodon* is based on *Pleurozium Schreberi*, which resembles it very closely in superficial appearance. As the *Pleurozium* is abundant in the region and is commonly associated with many of the other species reported, my certainty is justified. *Brotherella Roellii* is known only from Washington and British Columbia, but it is not easy to guess which Michigan species was so named, without seeing the actual specimen. The report of *Homalotheciella subcapillata* (Hedw.) Card. (as *Platygyrium brachyclados*) is likewise open to considerable doubt, and this species should not be included as a member of the Michigan flora until we have specimens upon which to base the record. The single "new species" proposed by Kindberg, *Hypnum* (*Campylium*) *sinuolatum*, has already been placed in synonymy by Grout (1928-40), who saw the type specimen and referred it to *Campylium chrysophyllum*.

It is unfortunate that Röhl's paper has been completely overlooked by Nichols, myself, and all other students of Michigan bryology until very recently, when I came across it quite by accident during the course of a routine search of bryological literature. This oversight was caused not only by the fact that the paper was published in a German publication (*Hedwigia*) covering all groups of cryptogams, but also because the specimens are not represented in any American herbarium. If the Purpus collection had been known, Röhl's report might have been looked for. With the exception of the few species already discussed, all those of Röhl's list have been discovered since and reported from other localities in Michigan.

In 1915 Kauffman published a list of 105 species of mosses and 26 species of hepatics which he and his students had collected in the southern part of the state. Except for his report of *Thamnium alleghaniense*, based on *Climacium dendroides* (Steere, 1934a), all his identifications have been confirmed through a study of his specimens or by later collections of the same species. In 1926 I became interested in the bryophytes of the Ann Arbor region and began to collect and study them. This investigation led to the discovery of a number of species not reported by Kauffman and, eventually, to the publication of several articles (Steere, 1931a, 1931b, 1933a, 1933b). My first list added 50 species to Kauffman's, and 18 to the flora of the state, whereas the supplement recorded 9 species for southern Michigan and 2 for the state. The important collections made in Kalamazoo County by H. R. Becker have added many species of great interest to the flora of the state (Nichols, 1932, 1933; Nichols and Steere, 1936) and one species new to science (*Buxbaumia cylindrica* Grout). Continued work in the Ann Arbor region has resulted in more additions to the flora of Michigan, which have been reported recently (Steere, 1942).

The bryophytes of the northern half of the Lower Peninsula have been studied with special intensity in the vicinity of the University of Michigan Biological Station, at Douglas Lake, Cheboygan County. The first bryological contribution from the station was a list of 10 species of *Sphagnum* reported by Praeger (1919), who had been stimulated to collect them by G. E. Nichols, at that time an authority on the use of *Sphagnum* in surgical dressings for World War I. Dr. Nichols joined the staff of the Biological Station in 1920, and in 1922 published the results of his bryological investigations during his

first two summers at Douglas Lake, in the form of a list of 261 species, of which no fewer than 101 were reported as new to the flora of Michigan (Nichols, 1922). Subsequent investigations during the next four summers resulted in a supplementary publication (Nichols, 1925), which added 14 more species to the state. He continued his collecting in the Douglas Lake region through the summer of 1938 and reported new records from time to time (Nichols and Steere, 1936). My connection with the Biological Station, beginning with the summer of 1939, has led to the addition of a number of species to Cheboygan, Emmet, and Presque Isle counties and to the flora of the state (Steere, 1942), and Darlington's collections from Leelenau County (1938) have further increased our knowledge of the wider distribution of bryophytes in the northern part of the Lower Peninsula. A paper by Irma Schnoorberger (1940), on the bryophytes of the central part of the Lower Peninsula, is of unusual interest since in the area covered we find the boundary between the hardwood forest flora of the south and the mixed coniferous forests of the north.

## II. THE UPPER PENINSULA

Collections from the Upper Peninsula are of two origins: (1) those from Isle Royale, and (2) those from the mainland. Isle Royale has received a remarkable amount of attention from botanists, in spite of its remoteness, so that its bryological flora is now better known than that of many other parts of the state which are much more accessible. In 1909 Holt published a list of 38 mosses which had been collected during an ecological study of Isle Royale. Cooper's papers (1912, 1913), likewise the result of an ecological study, raised the number of mosses known from Isle Royale to 104 species, and were soon followed by Conklin's report (1914) of 36 species of Hepaticae. Thus, within a period of five years, the northernmost and most inaccessible region of Michigan became the best known from a bryological viewpoint. Much more recently a thorough botanical survey of Isle Royale has greatly increased the known species, which now number 53 hepatics and 208 mosses (Thorpe and Povah, 1935). A few casual collections have added still other species (Cooper, 1928; Steere, 1942).

With the exception of a few species of somewhat doubtful identification (Povah, 1929), the bryophyte flora of the Upper Peninsula

between Isle Royale and Mackinac Island was practically unknown until the summer of 1933, when Nichols and I started field work there independently. My work in the Upper Peninsula began with a month's investigation (June, 1933) of the bryophytes of the Chase S. Osborn Preserve of the University of Michigan, on Sugar Island in St. Mary's River (Chippewa County) (Steere, 1943b). Much of July was spent in Alger County, both at the Pictured Rocks near Munising and in the vicinity of Au Train, and a brief trip was taken to the Keweenaw Peninsula. The Pictured Rocks were visited by Nichols in August, 1933, and a large number of species new to Michigan were collected by us (Nichols, 1933; Steere, 1934a), as well as one new species, *Barbula michiganensis* Steere (in Grout, 1928-40; Steere, 1939b).

During the summer of 1934 Nichols began a bryological investigation of the Huron Mountains in Marquette County (Nichols, 1935), which he continued during the summers of 1936 and 1937 (Nichols, 1938), and during the same summer I made extensive collections in Delta and Alger counties (Steere, 1934c). In 1935 Nichols and I started field work together in a survey of the Porcupine Mountains of Ontonagon County, which resulted in joint publication (Nichols and Steere, 1936, 1937). Earlier in 1934 I made an intensive study of the bryophytes of the Keweenaw Peninsula, which I had previously visited very briefly during 1933 (Steere, 1934a). A whole group of Rocky Mountain and Pacific Coast bryophytes of unusual significance was discovered (Steere, 1937), and further work in the same region during 1936 and 1937 led to the accumulation of more information on the distribution of these "critical" bryophytes (Steere, 1938, 1939a; Conard, 1938).

During the winter of 1936-37 Dr. Nichols and I compiled a preliminary list of the bryophytes of Michigan, which he prepared in mimeographed form in May, 1937, for use by his students at the University of Michigan Biological Station. This list contained the imposing total of 124 Hepaticae, 19 Sphagna, and 351 Musci. Unfortunately, Dr. Nichols' untimely death (Steere, 1939c) prevented the publication of our joint catalogue in the form which we had planned. Since further field work in all parts of the state has continued to add more species (Darlington, 1938; Schnoorberger, 1940, 1943; Steere, 1940, 1942), its completion has been postponed until now.

The following list of Michigan bryophytes contains 132 species of Hepaticae, 21 species of Sphagna, and 361 species of Musci. The nomenclature and arrangement of the liverworts and of Sphagnum follow the check lists recently published by Evans and Andrews (*The Bryologist*, 43: 132-138. 1940). The arrangement of the mosses and, to some extent, their nomenclature are taken from Brotherus' treatment in the second edition of Engler and Prantl's *Die natürlichen Pflanzenfamilien* (1924-25). The most appropriate name (in my opinion) is given for each species, and any other name under which it has been reported is added in parentheses. I shall be very grateful to users of this list who call to my attention any omissions from it, either of specimens or of literature which I have not seen.

## CHECK LIST OF THE BRYOPHYTES OF MICHIGAN

### HEPATICAE

#### PTILIDIACEAE

*Anthelia Juratzkana* (Limpr.) Trevis.  
*Blepharostoma trichophyllum* (L.) Dumort.  
*Ptilidium ciliare* (L.) Nees  
*Ptilidium pulcherrimum* (Web.) Hampe  
*Trichocolea tomentella* (Ehrh.) Dumort.

#### LEPIDOZIACEAE

*Bazzania trilobata* (L.) S. F. Gray  
*Lepidozia reptans* (L.) Dumort.  
*Microlepidozia setacea* (Spruce) Joerg. (*Lepidozia setacea* Mitt.)

#### CALYPOGEIACEAE

*Calypogeia fissa* (L.) Raddi  
*Calypogeia Neesiana* (Massal. & Carest.) K. Mull.  
*Calypogeia paludosa* Warnst.  
*Calypogeia sphagnicola* (Arn. & Pers.) Warnst. & Loeske  
*Calypogeia Trichomanis* (L.) Corda (includes report of *C. suecica*)

#### CEPHALOZIACEAE

*Cephalozia bicuspidata* (L.) Dumort.  
*Cephalozia catenulata* (Hüb.) Spruce  
*Cephalozia compacta* Warnst.  
*Cephalozia connivens* (Dicks.) Lindb.  
*Cephalozia lacinulata* (Jack) Spruce



Cephalozia Loitlesbergeri Schiffn.  
 Cephalozia Macounii Austin  
 Cephalozia media Lindb. (*C. lunulaefolia* Dumort.)  
 Cephalozia pleniceps (Aust.) Lindb.  
 Cladopodiella fluitans (Nees) Buch (*Cephalozia fluitans* Spruce)  
 Nowellia curvifolia (Dicks.) Mitt. (*Cephalozia curvifolia* Dumort.)  
 Odontoschisma denudatum (Mart.) Dumort.  
 Odontoschisma Macounii (Aust.) Underwood

#### CEPHALOZIELLIACEAE

Cephaloziella byssacea (Roth) Warnst.  
 Cephaloziella elachista (Jack) Schiffn.  
 Cephaloziella Hampeana (Nees) Schiffn. (includes report of *C. divaricata*)  
 Cephaloziella rubella (Nees) Douin  
 Cephaloziella Sullivantii (Aust.) Evans

#### HARPANTHACEAE

Chiloscyphus fragilis (Roth) Schiffn.  
 Chiloscyphus pallescens (Ehrh.) Dumort.  
 Chiloscyphus rivularis (Schr.) Loeske  
 Geocalyx graveolens (Schr.) Nees  
 Harpanthus scutatus (Web. & Mohr) Spruce  
 Lophocolea heterophylla (Schr.) Dumort.  
 Lophocolea minor Nees  
 Mylia anomala (Hook.) S. F. Gray

#### JUNGERMANNIACEAE

Anastrophyllum Michauxii (Web.) Buch (*Sphenolobus Michauxii* Steph.)  
 Barbilophozia barbata (Schmid.) Loeske (*Lophozia barbata* Dumort.)  
 Barbilophozia Hatcheri (Evans) Loeske (*Lophozia Hatcheri* Evans)  
 Barbilophozia lycopodioides (Wallr.) Loeske (*Lophozia lycopodioides* Cogn.)  
 Gymnocolea inflata (Huds.) Dumort. (*Lophozia inflata* M. A. Howe)  
 Isopaches bicrenatus (Schmid.) Buch (*Lophozia bicrenata* Dumort.)  
 Isopaches Hellerianus (Nees) Buch (*Sphenolobus Hellerianus* Steph.)  
 Jamesoniella autumnalis (DC.) Steph.  
 Jungermannia cordifolia Hook.  
 Jungermannia lanceolata L.  
 Jungermannia pumila With.  
 Jungermannia Schiffneri (Loitlesb.) Evans  
 Jungermannia sphaerocarpa Hook.  
 Leiocolea badensis (Gottsche) Joerg. (*Lophozia badensis* Schiffn.)  
 Leiocolea Gillmani (Aust.) Evans (*Jungermannia Gillmani* Aust.; *Lophozia Kaurini* (Limpr.) Steph.)  
 Leiocolea heterocolpa (Thed.) Buch (*Lophozia heterocolpa* M. A. Howe)  
 Leiocolea obtusa (Lindb.) Buch (*Lophozia obtusa* Evans)  
 Leiocolea Schultzii (Nees) Joerg.  
 Lophozia alpestris (Schleich.) Evans  
 Lophozia excisa (Dicks.) Dumort.  
 Lophozia incisa (Schr.) Dumort.

*Lophozia longidens* (Lindb.) Macoun  
*Lophozia marchica* (Nees) Steph.  
*Lophozia Mildeana* (Gottsche) Schiffn.  
*Lophozia porphyroleuca* (Nees) Schiffn.  
*Lophozia silvicola* Buch  
*Lophozia ventricosa* (Dicks.) Dumort.  
*Orthocaulis attenuatus* (Mart.) Evans (*Lophozia attenuata* Dumort.)  
*Orthocaulis Kunzeanus* (Hübner.) Buch (*Lophozia Kunzeana* Evans)  
*Plectocolea crenulata* (Smith) Evans  
*Plectocolea crenuliformis* (Aust.) Mitt. (*Nardia crenuliformis* Lindb.)  
*Plectocolea hyalina* (Lyell) Mitt. (*Nardia hyalina* Carringt.)  
*Sphenolobus minutus* (C'rantz) Steph.  
*Tritomaria exsecta* (Schmid.) Schiffn. (*Sphenolobus exsectus* Steph.)  
*Tritomaria exsectiformis* (Breidl.) Schiffn. (*Sphenolobus exsectiformis* Steph.)  
*Tritomaria quinquedentata* (Huds.) Buch (*Lophozia quinquedentata* Cogn.; *L. Lyoni* (Tayl.) Steph.)

#### MARSUPELLACEAE

*Marsupella emarginata* (Ehrh.) Dumort.  
*Marsupella sparsifolia* (Lindb.) Dumort.  
*Marsupella sphacelata* (Gies.) Dumort. (*M. Sullivantii* Evans)

#### PLAGIOCHILACEAE

*Plagiochila asplenioides* (L.) Dumort.

#### SCAPANIACEAE

*Diplophyllum apiculatum* (Evans) Steph.  
*Scapania apiculata* Spruce  
*Scapania curta* (Mart.) Dumort.  
*Scapania cuspiduligera* (Nees) K. Müll.  
*Scapania gymnostomophila* Kaal.  
*Scapania irrigua* (Nees) Dumort.  
*Scapania mucronata* Buch  
*Scapania nemorosa* (L.) Dumort.  
*Scapania paludicola* Loeske & K. Mull.  
*Scapania paludosa* K. Müll.  
*Scapania subalpina* (Nees) Dumort.  
*Scapania undulata* (L.) Dumort. (includes *S. dentata* Dumort.)  
*Scapaniella glaucocephala* (Tayl.) Evans (*Scapania glaucocephala* Aust.)

#### PORELLACEAE

*Porella pinnata* L.  
*Porella platyphylla* (L.) Lindb.  
*Porella platyphylloidea* (Schwein.) Lindb.

#### RADULACEAE

*Radula complanata* (L.) Dumort.  
*Radula obconica* Sulliv.

## FRULLANIACEAE

Frullania Asagrayana Mont.  
Frullania Bolanderi Aust.  
Frullania Brittoniae Evans  
Frullania eboracensis Gottsche  
Frullania inflata Gottsche  
Frullania Oakesiana Aust.  
Frullania Selwyniana Pears.

## LEJEUNEACEAE

Cololejeunea Biddlecomiae (Aust.) Evans  
Lejeunea cavifolia (Ehrh.) Lindb.

## FOSSOMBRONIACEAE

Fossombronia cristula Aust.  
Fossombronia foveolata Lindb.

## PELLIACEAE

Pellia epiphylla (L.) Corda  
Pellia Fabroniana Raddi  
Pellia Neesiana (Gottsche) Limpr.

## BLASIACEAE

Blasia pusilla L.

## PALLAVICINIACEAE

Moerckia Flotowiana (Nees) Schiffn. (*Pallavicinia Flotowiana* Lindb.)  
Pallavicinia Lyellii (Hook.) S. F. Gray

## METZGERIACEAE

Metzgeria conjugata Lindb.  
Metzgeria furcata (L.) Dumort.

## RICCARDIACEAE

Riccardia latifrons Lindb.  
Riccardia multifida (L.) S. F. Gray  
Riccardia palmata (Hedw.) Caruth.  
Riccardia pinguis (L.) S. F. Gray

## MARCHANTIACEAE

Conocephalum conicum (L.) Dumort. (*Conocephalus conicus* Hill)  
Lunularia cruciata (L.) Dumort.  
Marchantia polymorpha L.  
Preissia quadrata (Scop.) Nees (*P. commutata* Nees)

REBOULIACEAE

- Asterella Ludwigii (Schwaegr.) Underwood  
Mannia rupestris (Nees) Frye & Clark (*Grimaldia rupestris* Lindb.)  
Reboulia hemisphaerica (L.) Raddi

RICCIACEAE

- Riccia fluitans L.  
Ricciocarpus natans (L.) Corda (*Riccia natans* L.)

ANTHOCEROTACEAE

- Anthoceros laevis L.  
Anthoceros Macounii M. A. Howe  
Notothylas orbicularis (Schwein.) Sulliv.

MUSCI

SPHAGNACEAE

- Sphagnum capillaceum (Weiss) Schrank (*S. acutifolium* Ehrh.)  
Sphagnum compactum DC.  
Sphagnum cuspidatum Ehrh.  
Sphagnum Dusenii C. Jens.  
Sphagnum fimbriatum Wils.  
Sphagnum fuscum (Schimp.) H. Klinggr.  
Sphagnum Girgensohnii Russow  
Sphagnum magellanicum Brid.  
Sphagnum palustre L.  
Sphagnum papillosum Lindb.  
Sphagnum plumulosum Roll  
Sphagnum recurvum Beauv.  
    var. tenue H. Klinggr.  
Sphagnum robustum (Russow) Roll  
Sphagnum rubellum Wils. (*S. capillaceum* var. *tenellum* (Schimp.) Andr.)  
Sphagnum squarrosum Crome  
Sphagnum subbicolor Hampe  
Sphagnum subsecundum Nees (includes *S. platyphyllum* Sulliv.)  
Sphagnum tenellum Pers.  
Sphagnum teres (Schimp.) Aongstr.  
Sphagnum Warnstorffii Russow  
Sphagnum Wulfianum Girg.

ANDREAEACEAE

- Andreaea Rothii Web. & Mohr  
Andreaea rupestris Hedw. (*A. petrophila* Ehrh.)

GEORGIACEAE

- Tetraphis pellucida Hedw. (*Georgia pellucida* Rabenh.)  
Tetrodontium Brownianum (Dicks.) Schwaegr.

## FISSIDENTACEAE

- Fissidens adiantoides* Hedw.  
*Fissidens bryoides* Hedw.  
*Fissidens cristatus* Wils. (*F. decipiens* De Not.)  
*Fissidens grandifrons* Brid.  
*Fissidens incurvus* Schwaegr.  
*Fissidens Julianus* (Mont.) Schimp.  
*Fissidens obtusifolius* Wils.  
*Fissidens osmundioides* Hedw.  
*Fissidens subbasilaris* Hedw.  
*Fissidens taxifolius* Hedw.  
*Fissidens viridulus* (Web. & Mohr) Wahlenb.

## DITRICHACEAE

- Ceratodon purpureus* (Hedw.) Brid.  
*Distichium capillaceum* (Hedw.) BSG. (*Swartzia montana* Lindb.)  
*Distichium inclinatum* (Hedw.) BSG. (*Swartzia inclinata* Hedw.)  
*Ditrichum flexicaule* (Schwaegr.) Hampe  
*Ditrichum giganteum* Williams  
*Ditrichum lineare* (Sw.) Lindb. (*D. vaginans* (Sulliv.) Hampe)  
*Ditrichum pallidum* (Hedw.) Hampe  
*Ditrichum pusillum* (Hedw.) E. G. Britt. (*D. tortile* (Schrud.) Broeckm.)  
*Pleuridium subulatum* (Hedw.) Lindb. (*P. alternifolium* Rabenh.)  
*Saelania glaucescens* (Hedw.) Broth. (*S. caesia* Lindb.)

## SELIGERIACEAE

- Blindia acuta* (Hedw.) BSG.  
*Seligeria campylopoda* Kindb.  
*Seligeria Donniana* (Smith) C. Mull.  
*Seligeria pusilla* (Hedw.) BSG.  
*Seligeria recurvata* (Hedw.) BSG.

## DICRANACEAE

- Anisothecium Grevilleanum* (Brid.) Lindb. (*Dicranella Grevilleana* Schimp.)  
*Anisothecium Schreberianum* (Hedw.) Dixon (*Dicranella Schreberi* Schimp.)  
*Anisothecium varium* (Hedw.) Mitt. (*Dicranella rubra* (Huds.) Kindb.; *D. varia* Schimp.)  
*Bruchia Sullivantii* Aust.  
*Cnestrum Schisti* (Wahlenb.) Hagen  
*Cynodontium polycarpum* (Hedw.) Schimp. (*Oncophorus polycarpus* Brid.)  
*Cynodontium strumiferum* (Hedw.) De Not. (*Oncophorus strumiferus* Brid.)  
*Cynodontium tenellum* (BSG.) Limpr. (*Oncophorus tenellus* Williams)  
*Dichodontium pellucidum* (Hedw.) Schimp.  
     var. *fagimontanum* (Brid.) Schimp.  
*Dicranella heteromalla* (Hedw.) Schimp.  
*Dicranella subulata* (Hedw.) Schimp. (*D. secunda* (Sw.) Lindb.)  
*Dicranodontium denudatum* (Brid.) Hagen

*Dicranoweisia crispula* (Hedw.) Lindb.  
*Dicranum Bergeri* Bland. (*D. Schraderi* Web. & Mohr)  
*Dicranum Bonjeanii* De Not. (*D. palustre* BSG.)  
*Dicranum condensatum* Hedw. (*D. pallidum* BSG.)  
*Dicranum Drummondii* C. Müll.  
*Dicranum fragilifolium* Lindb.  
*Dicranum fulvum* Hook.  
*Dicranum fuscescens* Turn. (includes reports of *D. congestum* Brid.)  
*Dicranum Muehlenbeckii* BSG.  
*Dicranum scoparium* Hedw. (*D. scopariiforme* Kindb.)  
*Dicranum spurium* Hedw.  
*Dicranum undulatum* Turner (*D. rugosum* Brid.)  
*Dicranum viride* (Sulliv. & Lesq.) Lindb.  
*Oncophorus virens* (Hedw.) Brid.  
*Oncophorus Wahlenbergii* Brid.  
*Orthodicranum flagellare* (Hedw.) Loeske (*Dicranum flagellare* Hedw.)  
*Orthodicranum montanum* (Hedw.) Loeske (*Dicranum montanum* Hedw.)  
*Paraleucobryum longifolium* (Hedw.) Loeske (*Dicranum longifolium* Hedw.)  
*Rhabdoweisia denticulata* (Brid.) BSG.  
*Trematodon ambiguus* (Hedw.) Hornsch.

#### LEUCOBRYACEAE

*Leucobryum glaucum* (Hedw.) Schimp.

#### ENCALYPTACEAE

*Encalypta ciliata* Hedw.  
*Encalypta procera* Bruch  
*Encalypta rhabdocarpa* Schwaegr.  
*Encalypta streptocarpa* Hedw. (*E. contorta* (Wulf.) Lindb.)

#### POTTIACEAE

*Acaulon rufescens* Jaeg.  
*Astomum Muhlenbergianum* (Sw.) Grout (*A. Sullivantii* BSG.)  
*Barbula convoluta* Hedw.  
*Barbula cylindrica* (Tayl.) Schimp.  
*Barbula fallax* Hedw.  
*Barbula michiganensis* Steere  
*Barbula unguiculata* Hedw.  
*Didymodon recurvirostris* (Hedw.) Jennings (*D. rubellus* (Hoffm.) BSG.)  
*Didymodon rigidulus* Hedw.  
*Didymodon tophaceus* (Brid.) Jur.  
*Didymodon trifarius* (Hedw.) Brid. (*D. luridus* Hornsch.)  
*Gymnostomum aeruginosum* Smith (*G. rupestre* Schleich.)  
*Gymnostomum calcareum* Nees & Hornsch.  
*Gyroweisia tenuis* (Hedw.) Schimp.  
*Hymenostylium recurvirostrum* (Hedw.) Dixon (*H. curvirostre* (Ehrh.) Lindb.)  
*Phascum cuspidatum* Hedw. (*P. acaulon* L.)  
*Pottia truncata* (Hedw.) Fühnr. (*P. truncatula* (L.) Lindb.)  
*Tortella fragilis* (Drumm.) Limpr.

- Tortella humilis* (Hedw.) Jennings (*Barbula caespitosa* Schwaegr.; *Tortella caespitosa* Limpr.)  
*Tortella tortuosa* (Turner) Limpr.  
*Tortula intermedia* (Brid.) Berk.  
*Tortula mucronifolia* Schwaegr. (includes reports of *T. subulata*)  
*Tortula obtusifolia* Schwaegr.  
*Tortula papillosa* (Wils.) Spruce  
*Tortula ruralis* (Hedw.) Smith  
*Weisia viridula* Hedw. (*W. controversa* Hedw.)

## GRIMMIACEAE

- Grimmia alpicola* Hedw. var. *rivularis* (Brid.) Broth. (*Grimmia apocarpa* Hedw. var. *rivularis* Web. & Mohr)  
*Grimmia ambigua* Sulliv.  
*Grimmia anomala* Hampe (*G. Hartmani* Schimp. var. *anomala* Mönkem.)  
*Grimmia apocarpa* Hedw.  
*Grimmia commutata* Hübén.  
*Grimmia conferta* Funck  
*Grimmia gracilis* Schleich.  
*Grimmia Olneyi* Sulliv.  
*Grimmia ovalis* (Hedw.) Lindb. (*G. ovata* Schwaegr.)  
*Grimmia unicolor* Hook.  
*Rhacomitrium aciculare* (Hedw.) Brid.  
*Rhacomitrium canescens* (Hedw.) Brid.  
*Rhacomitrium fasciculare* (Hedw.) Brid.  
*Rhacomitrium heterostichum* (Hedw.) Brid.  
*Rhacomitrium microcarpon* (Hedw.) Brid. (*R. heterostichum* var. *ramulosum* (Lindb.) G. N. Jones)  
*Rhacomitrium patens* (Hedw.) Hübén. (*Grimmia patens* BSG.)  
*Rhacomitrium sudeticum* (Funck) BSG. (*R. heterostichum* var. *sudeticum* G. N. Jones)

## EPHEMERACEAE

- Ephemerum cohaerens* (Hedw.) Hampe  
*Ephemerum spinulosum* Schimp.

## FUNARIACEAE

- Aphanorrhagma serratum* (Hook. & Wils.) Sulliv.  
*Funaria hygrometrica* Hedw. (includes report of *F. flavicans*)  
*Physcomitrium turbinatum* (Michx.) Brid.

## SPLACHNACEAE

- Splachnum ampullaceum* Hedw.  
*Splachnum rubrum* Hedw.  
*Tetraplodon angustatus* (Hedw.) BSG.

## SCHISTOSTEGACEAE

- Schistostega pennata* (Hedw.) Hook. & Tayl. (*S. osmundacea* Mohr)

BRYACEAE

*Anomobryum filiforme* (Dicks.) Husnot

*Bryum argenteum* Hedw.

var. *lanatum* BSG.

*Bryum caespiticium* Hedw.

*Bryum capillare* Hedw.

*Bryum cernuum* (Hedw.) BSG. (*B. uliginosum* (Bruch) BSG.)

*Bryum cuspidatum* (BSG.) Schimp. (*B. affine* Lindb.; *B. intermedium* Brid.)

*Bryum inclinatum* (Web. & Mohr) Sturm

*Bryum Muehlenbeckii* BSG.

*Bryum pallens* (P. Beauv.) Röhl. (*B. fallax* Milde)

*Bryum pallescens* Schleich.

*Bryum pendulum* (Hornsch.) Schimp.

*Bryum pseudotriquetrum* (Hedw.) Schwaegr. (*B. binum* Turner; *B. ventricosum* Dicks.)

*Bryum tortifolium* Funck (*B. cyclophyllum* (Schwaegr.) BSG.)

*Bryum Weigelia* Spreng. (*B. Duvalii* Voit)

*Leptobryum pyriforme* (Hedw.) Schimp.

*Mielichhoferia Mielichhoferiana* (Funck) Limpr. (*M. nitida* Hornsch.)

*Mniobryum albicans* (Wahlenb.) Limpr. (*Pohlia Wahlenbergii* (Web. & Mohr) Andr.)

*Pohlia acuminata* Hoppe & Hornsch. (*Webera acuminata* Schimp.)

*Pohlia cruda* (Hedw.) Lindb. (*Webera cruda* Bruch)

*Pohlia elongata* Hedw.

*Pohlia nutans* (Hedw.) Lindb. (*Webera nutans* Hedw.)

*Pohlia prolifera* Lindb.

*Pohlia pulchella* (Hedw.) Lindb.

*Rhodobryum roseum* (Hedw.) Limpr. (*R. ontariense* (Kindb.) Paris)

MNIACEAE

*Cinclidium stygium* Sw.

*Mnium affine* Bland. (*M. rugicum* Laur.)

*Mnium ciliare* (Grev.) Lindb. (*M. affine* var. *ciliare* C. Müll.)

*Mnium cinclidioides* Hübner.

*Mnium cuspidatum* Hedw.

*Mnium Drummondii* BSG.

*Mnium lycopodioides* (Hook.) Schwaegr. (*M. riparium* Mitt.)

*Mnium medium* BSG.

*Mnium orthorrhynchum* Brid.

*Mnium punctatum* Hedw.

var. *elatum* Schimp.

*Mnium serratum* Brid. (*M. marginatum* P. Beauv.)

*Mnium spinulosum* BSG.

*Mnium stellare* Hedw.

*Mnium subglobosum* BSG.

AULACOMNIACEAE

*Aulacomnium androgynum* (Hedw.) Schwaegr.

*Aulacomnium heterostichum* (Hedw.) BSG.

*Aulacomnium palustre* (Hedw.) Schwaegr.



## MEESEACEAE

- Amblyodon dealbatus (Hedw.) P. Beauv.  
 Meesea triquetra (Turn.) Aongstr. (*M. tristicha* BSG).  
 Meesea uliginosa Hedw. (*M. trichodes* Spruce)  
 Paludella squarrosa (Hedw.) Brid.

## CATOSCOPIACEAE

- Catoscopium nigrum (Hedw.) Brid.

## BARTRAMIACEAE

- Bartramia ithyphylla Brid.  
 Bartramia pomiformis Hedw.  
 Philonotis caespitosa Wils. var. compacta Dismier  
 Philonotis fontana (Hedw.) Brid.  
 Philonotis marchica (Hedw.) Brid.  
 Plagiopus Oederi (Brid.) Limpr.

## TIMMIACEAE

- Timmia austriaca Hedw.  
 Timmia megapolitana Hedw. (*T. cucullata* Michx.)

## ORTHOTRICHACEAE

- Amphidium lapponicum (Hedw.) Schimp.  
 Drummondia prorepens (Hedw.) Jennings (*D. clavellata* Hook.)  
 Orthotrichum affine Brid.  
 Orthotrichum anomalum Hedw.  
 Orthotrichum elegans Hook. & Grev. (includes reports of *O. speciosum*)  
 Orthotrichum Lescurii Aust.  
 Orthotrichum Macounii Aust.  
 Orthotrichum obtusifolium Brid.  
 Orthotrichum ohioense Sulliv. & Lesq.  
 Orthotrichum pumilum Dick. (*O. fallax* Schimp.; *O. brachytrichum* Schimp.)  
 Orthotrichum sordidum Sulliv. & Lesq.  
 Orthotrichum stellatum Brid. (*O. Braunii* BSG.)  
 Orthotrichum strangulatum Schwaegr.  
 Ulota crista (Hedw.) Brid. (*U. crispula* Bruch; *U. ulophylla* Broth.)  
 Ulota Hutchinsiae (Smith) Schimp. (*U. americana* (P. Beauv.) Limpr.)  
 Ulota Ludwigii (Brid.) Brid.

## FONTINALACEAE

- Dichelyma capillaceum (Brid.) BSG.  
 Dichelyma falcatum (Hedw.) Myrin  
 Dichelyma pallescens BSG.  
 Dichelyma uncinatum Mitt.  
 Fontinalis antipyretica Hedw.  
     var. patula (Card.) Welch  
 Fontinalis biformis Sulliv.  
 Fontinalis disticha Hook. & Wils.

*Fontinalis Duriaci* Schimp.  
*Fontinalis gigantea* Sulliv.  
*Fontinalis hypnoides* Hartm.  
*Fontinalis Lescurii* Sulliv.  
*Fontinalis missourica* Card.  
*Fontinalis nitida* Lindb. & Arnell  
*Fontinalis novae-angliae* Sulliv.  
 var. *Groutii* Welsh

CLIMACIACEAE

*Climacium americanum* Brid.  
*Climacium dendroides* (Hedw.) Web. & Mohr  
*Climacium Kindbergii* (Ren. & Card.) Grout

HEDWIGIACEAE

*Hedwigia ciliata* Hedw. (*H. albicans* Lindb.)

CRYPHAEACEAE

*Forsstroemia trichomitria* (Hedw.) Lindb.

LEUCODONTACEAE

*Leucodon sciuroides* (Hedw.) Schwaegr.

NECKERACEAE

*Homalia Jamesii* Schimp.  
*Neckera pennata* Hedw.  
 var. *oligocarpa* (Bruch) Grout

THELIACEAE

*Myurella Careyana* Sulliv. (*M. gracilis* (Weinm.) Lindb.)  
*Myurella julacea* (Schwaegr.) BSG.  
*Thelia asprella* Sulliv.

FABRONIACEAE

*Anacamptodon splachnoides* (Frohl.) Brid.

LESKEACEAE

*Leskea arenicola* Best  
*Leskea gracilescens* Hedw.  
*Leskea obscura* Hedw.  
*Leskea polycarpa* Hedw.  
*Leskeella nervosa* (Schwaegr.) Loeske (*Leskea nervosa* Myrin)  
*Leskeella tectorum* (A. Braun) Hagen  
*Lindbergia Austinii* (Sulliv.) Broth. (*L. brachyptera* (Mitt.) Kindb. var. *Austinii* Grout)  
*Pseudoleskea atrovirens* (Dicks.) Best  
*Pseudoleskea oligoclada* Kindb.  
*Pseudoleskea radicata* (Mitt.) Lesq. & James  
*Pterigynandrum filiforme* Hedw.

## THUIDIACEAE

- Abietinella abietina* (Brid.) BSG. (*Thuidium abietinum* BSG.)  
*Anomodon attenuatus* (Hedw.) Hübén.  
*Anomodon minor* (P. Beauv.) Lindb.  
*Anomodon rostratus* (Hedw.) Schimp.  
*Anomodon Rugelii* (C. Mull.) Keissl. (*A. apiculatus* BSG.)  
*Anomodon viticulosus* (Hedw.) Hook. & Tayl.  
*Haplocladium microphyllum* (Hedw.) Broth. (*Thuidium microphyllum* Best)  
*Haplocladium virginianum* (Brid.) Lindb. (*Thuidium virginianum* Lindb.)  
*Haplohymenium triste* (Cesati) Kindb. (*Anomodon tristis* Sulliv.)  
*Helodium Blandowii* (Web. & Mohr) Warnst. (*H. lanatum* Broth.)  
*Helodium paludosum* (Sulliv.) Aust. (*Thuidium elodioides* Ren. & Card.)  
*Heterocladium squarrosulum* (Voit) Lindb.  
*Rauia scita* (P. Beauv.) Aust. (*Thuidium scitum* Aust.)  
*Thuidium delicatulum* (Hedw.) Mitt.  
*Thuidium minutulum* (Hedw.) BSG.  
*Thuidium Philiberti* Limpr.  
*Thuidium recognitum* (Hedw.) Lindb.

## AMBLYSTEGIACEAE

- Amblystegiella confervoides* (Brid.) Loeske  
*Amblystegiella subtilis* (Hedw.) Loeske  
*Amblystegium compactum* (C. Müll.) Aust  
*Amblystegium Juratzkanum* Schimp.  
*Amblystegium serpens* (Hedw.) BSG.  
*Amblystegium varium* (Hedw.) Lindb. (includes report of *A. radicale*)  
*Calliergon cordifolium* (Hedw.) Kindb. (*Hypnum cordifolium* Hedw.)  
*Calliergon giganteum* (Schimp.) Kindb.  
*Calliergon Richardsonii* (Mitt.) Kindb.  
*Calliergon stramineum* (Brid.) Kindb. (*Hypnum stramineum* Brid.)  
*Calliergon trifarium* (Web. & Mohr) Kindb. (*Drepanocladus trifarius* Broth.)  
*Calliergonella cuspidata* (Hedw.) Loeske (*Hypnum cuspidatum* Hedw.; *Acrocladium cuspidatum* Lindb.; *Calliergon cuspidatum* Kindb.)  
*Campylium chrysophyllum* (Brid.) Bryhn (*Hypnum chrysophyllum* Brid.; *Chrysohypnum chrysophyllum* Loeske; *Hypnum sinuolatum* Kindb.)  
*Campylium hispidulum* (Brid.) Mitt. (*Hypnum hispidulum* Brid.; *Chrysohypnum hispidulum* Roth)  
     var. *Sommerfeltii* (Myrin) Lindb. (*Chrysohypnum Sommerfeltii* Roth)  
*Campylium polygamum* (BSG.) Bryhn (*Chrysohypnum polygamum* Loeske)  
*Campylium stellatum* (Hedw.) Lange & C. Jens. (*Hypnum stellatum* Hedw.; *Chrysohypnum stellatum* Loeske)  
*Cratoneuron commutatum* (Hedw.) Roth  
*Cratoneuron filicinum* (Hedw.) Roth (*Hygroamblystegium filicinum* Loeske)  
*Drepanocladus aduncus* (Hedw.) Warnst. (*Hypnum aduncum* Hedw.; *D. Sendtneri* (Schimp.) Warnst.)  
     var. *Kneiffii* (BSG.) Warnst. (*D. Kneiffii* Warnst.)  
     var. *capillifolius* (Warnst.) Wynne  
*Drepanocladus exannulatus* (Gümb.) Warnst.  
     var. *Rotae* (De Not.) Grout  
*Drepanocladus fluitans* (Hedw.) Warnst. (*Hypnum fluitans* Hedw.)

- Drepanocladus revolvens* (Turn.) Warnst. (*D. intermedius* Warnst.)  
*Drepanocladus uncinatus* (Hedw.) Warnst. (*Hypnum uncinatum* Hedw.)  
*Drepanocladus vernicosus* (Lindb.) Warnst. (*Hypnum vernicosum* Lindb.)  
*Hygroamblystegium fluviatile* (Hedw.) Loeske (*Amblystegium fluviatile* BSG.)  
*Hygroamblystegium irriguum* (Wils.) Loeske (*Amblystegium irriguum* BSG.)  
     var. *spinifolium* (Schimp.) Grout  
*Hygroamblystegium noterophilum* (Sulliv.) Warnst. (*Amblystegium noterophilum* Holz.)  
*Hygroamblystegium orthocladum* (P. Beauv.) Grout (*Amblystegium orthocladum* Card.)  
*Hygrohypnum dilatatum* (Wils.) Loeske  
*Hygrohypnum eugyrium* (BSG.) Loeske  
*Hygrohypnum luridum* (Hedw.) Dixon (*H. palustre* (Huds.) Loeske)  
     var. *subsphaericarpum* (Schleich.) (includes report of *H. polare*.)  
*Hygrohypnum molle* (Schimp.) Loeske  
*Hygrohypnum ochraceum* (Turn.) Loeske  
*Leptodietyum Kochii* (BSG.) Warnst. (*Amblystegium Kochii* BSG.)  
*Leptodietyum riparium* (Hedw.) Warnst. (*Amblystegium riparium* BSG.)  
*Leptodietyum trichopodium* (Schultz) Warnst.  
*Pleurozium Schreberi* (Brid.) Mitt. (*Hypnum Schreberi* Brid.; *Calliergon Schreberi* Grout; *Calliergonella Schreberi* Grout)  
*Scorpidium scorpioides* (Hedw.) BSG. (*Hypnum scorpidioides* Hedw.; *Drepanocladus scorpidioides* Warnst.)

# BRACHYTHECIACEAE

- Brachythecium acutum* (Mitt.) Sulliv.  
*Brachythecium Bestii* Grout  
*Brachythecium campestre* BSG.  
*Brachythecium digastrum* C. Müll. & Kindb.  
*Brachythecium flexicaule* Ren. & Card.  
*Brachythecium oxycladon* (Brid.) Jaeg. & Sauerb. (*B. laetum* (Brid.) BSG.)  
     var. *dentatum* (Lesq. & James) Grout  
*Brachythecium plumosum* (Hedw.) BSG.  
*Brachythecium populeum* (Hedw.) BSG.  
*Brachythecium reflexum* (Starke) BSG.  
*Brachythecium rivulare* BSG.  
*Brachythecium rutabulum* (Hedw.) BSG.  
*Brachythecium salebrosum* (Web. & Mohr) BSG.  
*Brachythecium Starkei* (Brid.) BSG.  
*Brachythecium velutinum* (Hedw.) BSG.  
*Bryhnia graminicolor* (Brid.) Grout  
*Bryhnia novae-angliae* (Sulliv. & Lesq.) Grout  
*Chamberlainia acuminata* (Hedw.) Grout (*Brachythecium acuminatum* Kindb.)  
*Chamberlainia cyrtophylla* (Kindb.) Grout (*Brachythecium cyrtophyllum* Kindb.)  
*Cirriphyllum piliferum* (Hedw.) Grout  
*Eurhynchium diversifolium* (Schleich.) BSG.  
*Eurhynchium hians* (Hedw.) Jaeg. & Sauerb.  
*Eurhynchium pulchellum* (Hedw.) Dixon (*E. strigosum* (Hoffm.) BSG.)  
     var. *praecox* (Hedw.) Dixon (*E. strigosum* var. *praecox* Limpr.)  
*Platyhypnidium riparioides* (Hedw.) Dixon (*Eurhynchium rusciforme* Milde;

- Oxyrrhynchium rusciforme* Warnst; *P. rusciforme* Fleisch; *Hygrohypnum Nicholsii* (Grout)  
*Rhynchostegium serrulatum* (Hedw.) Jaeg. & Sauerb. (*Eurhynchium serrulatum* Kindb.)  
*Tomenthypnum nitens* (Hedw.) Loeske (*Camptothecium nitens* Schimp.)

## ENTODONTACEAE

- Entodon cladorrhizans* (Hedw.) C. Müll. (*Cylindrothecium cladorrhizans* Schimp.)  
*Entodon seductrix* (Hedw.) C. Müll. (*Cylindrothecium seductrix* Sulliv.)

## PLAGIOTHECIACEAE

- Isopterygium deplanatum* (Sulliv.) Grout (*Plagiothecium deplanatum* Grout; *Taxiphyllum deplanatum* Fleisch.; *Rhynchostegium deplanatum* Schimp.)  
*Isopterygium elegans* (Hook.) Lindb. (*Plagiothecium elegans* Sulliv.)  
*Isopterygium Muellierianum* (Schimp.) Lindb. (*Plagiothecium Muellierianum* Schimp.)  
*Isopterygium pulchellum* (Hedw.) Jaeg.  
*Isopterygium turfaccum* (Lindb.) Lindb. (*Plagiothecium turfaccum* Lindb.)  
*Plagiothecium denticulatum* (Hedw.) BSG.  
*Plagiothecium laetum* BSG.  
*Plagiothecium Roeseanum* (Hampe) BSG. (*P. Roesei* Hampe)  
*Plagiothecium Ruthei* Lämpr.  
*Plagiothecium striatellum* (Brid.) Lindb.  
*Plagiothecium sylvaticum* (Brid.) BSG.

## SEMATOPHYLLACEAE

- Brotherella delicatula* (James) Fleisch. (*Rhaphidostegium laxepatulum* Lesq. & James)  
*Brotherella recurvans* (Michx.) Fleisch. (*Stereodon recurvans* Broth.)  
*Brotherella tenuirostris* (Schimp.) Broth.  
*Heterophyllum Haldanianum* (Grev.) Kindb. (*Hypnum Haldanianum* Grev.)

## HYPNACEAE

- Breidleria arcuata* (Lindb.) Loeske (*Hypnum arcuatum* Lindb.; *Hypnum patentiae* Lindb.; *Stereodon Lindbergii* Warnst.)  
*Breidleria pratensis* (Koch) Loeske (*Hypnum pratense* Koch; *Stereodon pratensis* E. G. Britt.)  
*Ctenidium molluscum* (Hedw.) Mitt. (*Hypnum molluscum* Hedw.)  
*Homomallium adnatum* (Hedw.) Broth.  
*Hypnum pallescens* (Hedw.) BSG. (*Stereodon pallescens* Lindb.)  
*Hypnum curvifolium* Hedw.  
*Hypnum fertile* Sendt.  
*Hypnum imponens* Hedw. (*Stereodon imponens* Lindb.)  
*Hypnum pallescens* (Hedw.) BSG. (*Stereodon pallescens* Lindb.)  
*Hypnum reptile* Michx. (*Stereodon reptilis* Mitt.)  
*Platygyrium repens* (Brid.) BSG.  
*Ptilium crista-castrensis* (Hedw.) De Not. (*Hypnum crista-castrensis* Hedw.)  
*Pylaisia intricata* (Hedw.) BSG.  
*Pylaisia polyantha* (Hedw.) BSG.

*Pylaisia Selwynii* Kindb. (*P. Schimperii* Card.)

*Pylaisia subdenticulata* Schimp.

RHYTIDIACEAE

*Rhytidiadelphus squarrosus* (Hedw.) Warnst.

*Rhytidiadelphus triquetrus* (Hedw.) Warnst. (*Hylocomium triquetrum* Hedw.)

*Rhytidium rugosum* (Hedw.) Kindb.

HYLOCOMIACEAE

*Hylocomiastrum pyrenaicum* (Spruce) Fleisch. (*Hylocomium pyrenaicum* Lindb.)

*Hylocomium splendens* (Hedw.) BSG. (*H. proliferum* (L.) Lindb.)

*Hylocomium umbratum* (Hedw.) BSG.

BUXBAUMIACEAE

*Buxbaumia aphylla* Hedw.

*Buxbaumia subcylindrica* Grout (includes report of *B. indusiata*)

DIPHYSICIACEAE

*Diphyscium foliosum* (Hedw.) Mohr (*D. sessile* (Schmid.) Lindb.; *Webera sessilis* Lindb.)

POLYTRICHACEAE

*Atrichum angustatum* (Brid.) BSG. (*Catharinaea angustata* Brid.)

*Atrichum crispum* (James) Sulliv.

*Atrichum Macmillani* (Holz.) Frye

*Atrichum undulatum* (Hedw.) P. Beauv. (*Catharinaea undulata* Web. & Mohr)

*Pogonatum capillare* (Michx.) Brid.

*Pogonatum alpinum* (Hedw.) Rohl. (*Polytrichum alpinum* Hedw.)

*Polytrichum commune* Hedw.

*Polytrichum formosum* Hedw.

*Polytrichum gracile* Smith

*Polytrichum juniperinum* Hedw.

*Polytrichum ohioense* Ren. & Card. (*P. decipiens* Limpr.)

*Polytrichum piliferum* Hedw.

*Polytrichum strictum* Smith

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# ALGAE COLLECTED BY THE "HASSLER," "ALBATROSS," AND SCHMITT EXPEDITIONS

## III. MARINE ALGAE FROM PERU AND CHILE

WM. RANDOLPH TAYLOR

### INTRODUCTION

**I**N TWO other contributions (Taylor, 1930, p. 627; 1939, p. 127) the writer has dealt with algae from the chief expeditions with whose collections this paper is concerned. Since in the introductions to them descriptions of the expeditions and citations of sources of information respecting them have been given, little more need be written here. In brief, the U.S.C.S. Steamer "Hassler," when she sailed to her West Coast station, carried a scientific staff under the direction of Louis Agassiz. She left Boston in December, 1871, and reached San Francisco in August, 1872; the part of the trip covered by this present paper, comprising the northern Chilean and Peruvian collections, was all in the year 1872. Not included here are the bulk of the algae from the Juan Fernandez Islands, which have been sent to Dr. Tore Levring of Lund, Sweden, to use in conjunction with other material in a paper (Levring, 1941) on the algae of that island group. The algae of Ecuador, principally those of the Galapagos Islands, from all three sources contributing to this series of papers, have been incorporated in a report now recently issued (1945). There is little of "Albatross"<sup>1</sup> material concerned in the present paper; that which the expedition secured in the Galapagos and Revillagigedo islands has also been included in the paper just mentioned. Of "Hassler"<sup>1</sup>

<sup>1</sup> The material from the "Hassler," "Albatross," and Schmitt expeditions reached the writer either in fluid or unsorted on paper, without being provided with individual numbers. The present author, when mounting and arranging these collections, assigned serial numbers in each case, in order to provide for the identification of the duplicate material. These numbers should not be interpreted as indicating any original sequence of collection in the field or in the herbarium.

material there remains a little from Baja California and southern California, but probably not enough to justify separate publication. There is also a suite of specimens to the present not associated with any reliable data; should their geographic source be ascertained later, they will be worth reporting upon.

It is still too early to draw any very detailed conclusions on floristic matters for this area. As the writer has recently determined, the flora of the Galápagos Islands, though hardly completely tropical, especially in the southern islands, in no great measure resembles that of Peru. The flora of mainland Ecuador is less known than that of Peru, and the transition region, though probably in southern Ecuador, has not been distinguished for lack of adequately extensive records. We have a fairly good idea of the flora of the Strait of Magellan; the floras of central and northern Chile clearly involve a considerable change, for some of the characteristic large things from farther south do not occur there. However, we as yet know little of the marine flora of Chile above the Strait (Montagne, 1852). The flora of the Juan Fernandez Islands is the best known of this region from Levring's reports (1941, 1942). Previously the only special algal paper on the islands was the small one by Montagne (1835). On the mainland so far north a number of warm-water species begin to appear in the flora, large codiums and *Padina*, for example. The flora of Easter Island (*Rapa Nui*) reported by Børgesen has a Caribbean aspect with in general the same genera and similar, though not identical, species. Easter Island is nearly in the latitude of Caldera, but far west of the Humboldt Current, which lowers the temperature of the water along the mainland as far north as the Galápagos Islands and perhaps in somewhat lesser proportion that about the Juan Fernandez Islands. These islands are a good deal farther south than Easter Island, about seven degrees of latitude, but seem to have some warm-water species not yet recorded from the opposite mainland.

The "Hassler" and "Albatross" material was made available by the kindness of Dr. C. W. Dodge and, later, Dr. D. H. Linder, curators of the Farlow Herbarium, Harvard University. The algae collected by Dr. Waldo L. Schmitt<sup>2</sup> while on a Walter Rathbone Bacon Scholarship during 1925-27 are an important element in the present paper, and with them are materials which he collected in 1935 while

<sup>2</sup> See footnote 1.

on the Allan Hancock Expedition of the University of Southern California of that year. A small addition came from specimens received from the Chicago Natural History Museum kindly sent by the curator of cryptogams, Dr. Francis Drouet, collected by Sr. Angel Maldonado in 1942, and one important sample of rough-dried material collected by Professor H. H. Bartlett of the University of Michigan, from Antofagasta, Chile. To all these contributors of algae the writer desires to express his gratitude. As detailed before (1939, p. 129), various institutions have granted special facilities for comparison of this material with their own collections; one must add to those already mentioned the names of Dr. Fred J. Seaver, New York Botanical Garden; Dr. F. W. Pennell, Philadelphia Academy of Natural Sciences; and Dr. H. L. Mason, University of California. The late Dr. M. A. Howe, of New York, and Drs. W. A. Setchell and N. L. Gardner, of Berkeley (who often reported jointly), made determinations of several specimens in which they were interested. Dr. G. J. Hollenberg kindly determined specimens of *Polysiphonia*, and Dr. G. F. Papenfuss helped to locate useful specimens at Berkeley. Professor H. H. Bartlett kindly prepared the Latin diagnoses of new species.

## LIST OF SPECIES

### CHLOROPHYCEAE

#### ULVACEAE

**ENTEROMORPHA BULBOSA** (Suhr) Mont. — Plants gregarious, 3–10 cm. tall, very slender and sparingly branched from near the base, the mature branches to 3 mm. diam., straight or somewhat compressed and contorted; cells to 15–22  $\mu$  diam., somewhat regularly arranged but not in long, evident rows, of irregular shape and with rounded angles, the lateral cell walls rather thin, the inner and outer walls distinctly thicker.

Peru: Herradura, from fresh water, *Schmitt* 181, Oct. 31, 1926. Paíta, rocks south of the railroad station, *Schmitt* 546, Oct. 6, 1926. Chile: Caldera, *Hassler* 1128 (?), 1872.

*References:* Suhr, 1839, p. 72, pl. 4, fig. 46, as *Solenia bulbosa*. Montagne, 1846, p. 3. Howe, 1914, p. 22.

The description based on the Peruvian specimens shows forms which in general size and cell size do not reach the extremes cited by Howe (1914, p. 23). The Chilean material is larger and lighter in color, with somewhat thicker cell walls.

ENTEROMORPHA COMPRESSA (L.) Grev. — Peru: Paita, *Hassler 97*, 1872.

*References:* Montagne, 1846, p. 3. Taylor, 1937, p. 64.

Montagne (*loc. cit.*) records this species from Paita; though it is probably absent from the intermediate tropical seas, it seems to be present on the north and south American Pacific shores.

ENTEROMORPHA INTESTINALIS (L.) Grev. — Peru: Herradura, *Schmitt 176*, Oct. 31, 1926.

*References:* Montagne, 1839, pp. 3, 5. Taylor, 1937, p. 65, pl. 3, fig. 7.

ENTEROMORPHA LINGULATA J. Ag. — Peru: Paita, *Hassler 95*, 1872. Chile: Arica, *Hassler 14*, 1872.

*Reference:* Taylor, 1942, p. 13.

These very slender plants agree in most respects with the description given earlier by the writer (*loc. cit.*), but the cells are rather smaller, generally 7-9  $\mu$  diam.

ENTEROMORPHA LINZA (L.) J. Ag. — Chile: Arica, *Hassler 10, 11, 12*, 1872.

*Reference:* Taylor, 1937, p. 68, pl. 3, fig. 8.

Since the bases of these plants are missing or obscured and the blades untidily mounted, the writer found them not fully satisfactory for study. The blade thickness was about 30  $\mu$ , which so far confirmed the determination.

ULVA FASCIATA Delile f. COSTATA Howe. — Peru: Punta Talara, *Schmitt 166*, Aug. 29, 1926. Paita, *Hassler 90*, 1872; *ibid.*, rocks north of the railroad station, *Schmitt 545* (?), Oct. 6, 1926. Islas Lobos de Afuera, shore rocks, *Schmitt 391F 35*, Jan. 17, 1936. Callao, *Maldonado 300*, June, 1942; *ibid.*, on Isla San Lorenzo, *Schmitt 197*, Nov. 3, 1926. Salaverry, on wreckage, *Schmitt 574*, Oct. 21, 1926.

*Reference:* Howe, 1914, p. 20.

ULVA LACTUCA L. var. LATISSIMA (L.) De Cand. — Chile: Arica, *Hassler 9, 13*, 1872.

*Reference:* Taylor, 1937, p. 75.

ULVA LACTUCA L. var. RIGIDA (C. Ag.) Le Jol. — Peru: Paita,

*Hassler 85, 106.* Callao, at Isla San Lorenzo, *Schmitt 189 (?)*, Nov. 1, 1926; *ibid.*, dredged, *Schmitt 204 (?)*, Nov. 7, 1926.

*Reference:* Taylor, 1937, p. 75.

### VALONIACEAE

**MICRODICTYON JAPONICUM** Setchell. — Chile: Islas Juan Fernandez, dredged in 27–37 meters in Bahía Carbajal, *Schmitt 149*, Dec. 15, 1926, det. Setchell; *ibid.*, at Isla Santa Clara, *Schmitt 133*, Dec. 11, 1926.

*Reference:* Setchell, 1929, p. 528, figs. 49–56.

### CLADOPHORACEAE

**CHAETOMORPHA ANTENNINA** (Bory) Kütz. f. — Chile: Caldera, *Hassler 1126*, 1872.

*Reference:* Taylor, 1945, p. 52.

**Chaetomorpha peruviana**, sp. nov. — Plants tufted, 5–7 cm. tall, the filaments dark green and stiff; cell walls of moderate thickness; basal cell to 720–850  $\mu$  long, at the bottom discoid-expanded and lobed, at the top about one fifth as broad as long; filaments 125–240  $\mu$  diam., the cells subequal to twice as long as broad, slightly swollen; in the upper portion the fertile cells considerably swollen, to 320  $\mu$  diam.

Peru: Paita, *Hassler 96*, 1872 (TYPE). Chile: Lota, *Hassler 1138*, 1872.

Plantae caespitosae, 5–7 cm. altae, filamentis atriviridibus, rigidis, 125–240  $\mu$  diam., membrana cellularum modice crassa; cellulis subaequalibus vel bis longioribus quam latoribus, paulum tumidis, in parte filamenti superiore cellulis fertilibus distincte tumidis, grandioribus 320  $\mu$  diam.; cellula basali longitudine 720–850  $\mu$  attingente, basi discoidali expansa et lobata, prope apicem circa quinquies longiore quam crassiore.

Peru, in loco dicto Paita; legit "Hassler Expedition," 96, 1872.

Howe (1914, p. 36) describes *C. cartilaginea* as coarser than *C. aerea* (Dillw.) Kütz.; here we have a plant somewhat softer than *C. aerea* usually is, but with overlapping characters and very hard to define as distinct from that species. What appears to be a variant from *Herradura* is much taller and softer, but in warm

tide pools a parallel variant of the New England *C. aerea* is occasionally found. On the whole, it is probable that these South American plants are specifically distinct, about one third more slender, softer and perhaps of darker color than their northern counterparts.

**CHAETOMORPHA PERUVIANA** var. **elongata**, var. nov. — Plants (detached) probably more than 15 cm. tall, dark green, flexuose but not notably entangled, the base (of young epiphytic filaments) with a small simple irregularly discoid holdfast, the basal cell above this somewhat club-shaped, below 45–58  $\mu$  diam., above 70–115  $\mu$  diam. and 700–930  $\mu$  long (but no doubt larger in mature filaments); cell next above the basal cell little broader, to 2–3 diameters long; cells of most of the mature filaments 0.75–2.0 diameters long and little contracted at the nodes; upper cells of older filaments 190–225  $\mu$  diam., 225–385  $\mu$  long, markedly cask-shaped; uppermost and apparently sporangial cells when empty subspherically much distended to 360  $\mu$  diam., those below likewise but somewhat less strongly distended, to 255–290  $\mu$  diam., 255–385  $\mu$  long.

Peru: Herradura, *Schmitt* 178, Oct. 31, 1926 (TYPE).

Plantae plus quam 15 cm. altae, juventate parte superiore cellulae basalis claviformi, 8-plo longiore quam latiore, parte inferiore irregulari disciformi; filamentum sursum ex cellulis tumidis 190–225  $\mu$  diam., 225–385  $\mu$  longis constanti; cellulis sporangialibus minus quam 360  $\mu$  diametentibus, subglobosis.

Peru, in loco dicto Herradura; legit Schmitt, 178, 1926.

**CHAETOMORPHA CARTILAGINEA** Howe. — Peru: Callao, dredged from 5.4 meters' depth parallel to Isla San Lorenzo, *Schmitt* 364B–35, Jan. 10, 1935.

*Reference:* Howe, 1914, p. 36, pl. 3, figs. 11–13; pl. 5.

These specimens seem identical in character with those described by Howe (*loc. cit.*) from the region of Callao, differing in the same way from the type and likewise lacking elongate basal cells.

**RHIZOCLONIUM TORTUOSUM** (Dillw.) Kütz. — Filaments entangled, dull green, irregular, to 45–95  $\mu$  diam., the cells slightly swollen, to 0.8–1.5 diameters long; holdfasts apparently absent.

*Reference:* Taylor, 1937, p. 83.

Chile: Arica, *Hassler* 7, 8, 1872.

## BRYOPSIDACEAE

**BRYOPSIS RHIZOPHORA** Howe. — Peru: Salaverry, along the shore, *Schmitt* 566, 567, Oct. 18, 1926; *ibid.*, south of the pier, *Schmitt* 569, Oct. 19, 1926.

*Reference:* Howe, 1914, p. 38, pl. 6, fig. A; pl. 7.

**BRYOPSIS ROSAE** Gaud. — Chile: Arica, *Hassler* 6, 1872.

*References:* Bory de St. Vincent, 1827–29, p. 211, pl. 24, fig. 1.

Hooker f. and Harvey, 1847 (II), p. 492. Hylmö, 1919, p. 14.  
Taylor, 1939, p. 135.

**Bryopsis peruviana**, sp. nov. — Plants dark green, to 7 cm. tall or perhaps somewhat more, gregarious, at the bases erect or somewhat entangled, the holdfasts lobed, somewhat rhizoidal; the erect axes to 680–770  $\mu$  diam., simple or generally in the lower portion sparingly branched, the branches erect or ascending, similar to the axes; branches distally distichously beset with short pinnules, forming narrow very acute-tipped blades, which become 2.5 cm. long, 5 mm. broad, the pinnules ascending, slightly up-curved, to 3.5 mm. long, reaching 130–200  $\mu$  diam., or to 250  $\mu$  when bearing a few small secondary pinnules; branches at the base often bearing a few short, decurrent rhizoids, but without extensive rhizoidal cortication. Plate II, Figure 1.

Peru: Paita, *Hassler* 80 (TYPE), 94, 1872.

Plantae atrivirides, plus minusve 7 cm. altae, gregariae, erectae vel deorsum intertextae, hapteris lobatis vel paulum rhizoidalibus; axibus plerumque 680–770  $\mu$  diam., simplicibus vel in parte inferiore sparse ramosis, sursum distiche vestitis cum pinnulis brevibus 130–200  $\mu$  diam., laminas angustas acutas formantibus; rhizoideis paucis, parvis, ad bases ramorum inferiorum sitis, haud corticem rhizoidalem formantibus.

Peru, in loco dicto Paita; legit "Hassler Expedition," 80, 1872.

These plants differ from *B. corticulans* in their crowded growth habit, sparse erect branching, dark color and slight rhizoidal growth from the branches. In habit they exactly resemble specimens of *B. muscosa* Lamour., except for the strictly distichous blades and the small growths from the bases of the branches. In spite of Howe's warning (1914, p. 39), the writer feels that it is best to describe this plant as new.



## CAULERPACEAE

CAULERPA FLAGELLIFORMIS C. Ag. f. LIGULATA (Harv.) Weber-van Bosse. — Peru: Islas Lobos de Afuera, on shore rocks, *Schmitt 391A-35*, Jan. 17, 1935; *ibid.*, dredged from 25-29 meters' depth in South Bay, *Schmitt 395A-35*, Jan. 17, 1935.

*References:* Harvey in J. Agardh, 1872, p. 10. Weber-van Bosse, 1898, p. 273, pl. 24, fig. 7. Howe, 1914, p. 42, pl. 8.

## CODIACEAE

CODIUM SETCHELLII Gardn. — Chile: Tocopilla, *Schmitt 159*, Nov. 15, 1926.

*References:* Schmidt, 1923, p. 28. Taylor, 1939, p. 135.

CODIUM FERNANDEZIANUM Setch. — Chile: Islas Juan Fernandez, *Hassler*, det. Setchell.

*Reference:* Setchell, 1937, p. 592, pls. 35-38; text figs. 15, 41-48.

CODIUM PERUVIANUM (Howe) Setch. — Peru: Paita, *Hassler 93 (?)*, 1872; *ibid.*, rocks north of the railroad station, *Schmitt 547*, Oct. 6, 1926; *ibid.*, dredged offshore north of the town, *Schmitt 555*, Oct. 7, 1926. Islas Lobos de Afuera, shore rocks, *Schmitt 391D-35*, Jan. 19, 1935.

*References:* Howe, 1914, p. 43, pl. 9. Setchell, 1937, p. 597.

CODIUM UNILATERALE Setchell & Gardn. f. SKOTTSBERGIANUM Setchell. — Chile, Islas Juan Fernandez, *Hassler*, 1872, det. Setchell.

*Reference:* Setchell, 1937, p. 596, pl. 38, fig. 16.

## PHAEOPHYCEAE

## CHORDARIACEAE

MYRIOCLADIA GRANDIS Howe. — Peru: Callao, dredged from 5.4 meters' depth near Isla San Lorenzo, *Schmitt 364C-35*, Jan. 10, 1935.

*Reference:* Howe, 1914, p. 53. pls. 12-13, figs. 10-20.

## ASPEROCOCCACEAE

COLPOMENIA SINUOSA (Roth) Derb. & Sol. — Peru: Paita, dredged off the shore north of the town, *Schmitt*, Oct. 7, 1926. North

Chinchas Island, Chicago Nat. Hist. Mus., 1013285. Bahía Independencia, dredged from 9 meters' depth east of Isla Vieja, Schmitt 371B-35, Jan. 12, 1935.

References: Howe, 1914, p. 50. Taylor, 1928, p. 110.

*COLPOMENIA SINUOSA* f. *lacunosa* f. nov. -- Plants forming cushions 1.0-1.5 cm. thick and 2-5 cm. or more broad, dull brownish, darkening on drying; thallus very irregular, of divisions 2-5 mm. broad, in the lower parts becoming lacunose, above the surface irregular with short projecting lobes or free branches about as long as broad, or the branches coherent; surface cells angular, 4.5-10.0  $\mu$  diam., from alcoholic material, the thallus wall about 350-400  $\mu$  thick, the inner medullary cells in 2-3 layers and very large, the outer medullary cells sharply smaller, in 2-3 layers of equally colorless cells; cortex a single layer of chromatophore-rich cells, about 6-9  $\mu$  tall, about as broad or a little less.

Peru: Hassler 84, 107, 1872; *ibid.*, rocks north of the railroad station, Schmitt 541 (TYPE), Oct. 6, 1926. Bahía Independencia, from the shore, Schmitt 380A-35, Jan. 14, 1935.

Plantae caespitosae, caespites 1.0-1.5 cm. crassos, 2-3 cm. latos integrantes; thallo irregulari, divisionibus 2-5 mm. latis, in parte inferiore lacunoso et lobis divergentibus vel ramis liberis latitudine longitudinem aequantibus praedito.

Peru, in loco dicto Paita; legit Schmitt, 541, 1926.

This plant is a very puzzling one. It was at first taken for *Hydroclathrus clathratus* (Bory) Howe, which has been reported from Peru (Skottsberg, 1941, p. 683, but not Howe, 1914). However, it is smaller and more compact; there is no large, well-developed net system such as is evident in good *Hydroclathrus*, and free terminal lobes are common, if small. It may be compared with *Colpomenia ramosa* Taylor (1945, p. 84) from Baja California and Costa Rica, but it is a much more compact plant, lacunose below, and the free surface branches are very much shorter and simpler. A form parallel to this one is *Colpomenia sinuosa* f. *tuberculata* (Saund.) Setchell & Gardner (1925, p. 541; Phyc. Bor.-Amer. 826), but that is more minutely divided and thicker-walled. Unfortunately, little but dried material was available and, since the form is not restored on soaking, it is not practicable to give good habit illustrations of it.

## SPHACELARIACEAE

HALOPTERIS HORDACEA (Harv.) Sauv. — Chile: Antofagasta, washed ashore in tidal pools on the rocky coast, *H. H. Bartlett* 19020, Sept. 9, 1942. Plate I, Figure 1; Plate III.

*References:* Harvey, 1844, pl. 614 (as *Sphacelaria hordacea*). Reinke, 1890, p. 27, pl. 7, figs. 6–9 (as *Stypocaulon paniculatum*). Sauvageau, 1900–14, pp. 416–433. (Perhaps *Sphacelaria paniculata* Suhr, 1840, p. 278, regarding which see Sauvageau, *loc. cit.*)

A considerable amount of this plant was secured. The largest piece was 36 cm. tall. The habit varied a good deal. The upper branching of young plants was corymbiform and somewhat resembled *H. scoparia* (Kütz.) Sauv. Fertile plants were paniculate, not corymbiform, in aspect; they were sometimes dense and with very dense fruiting tips; these were sporangial plants. Other looser ones were presumably sexual, but the reproductive organs were not clearly preserved in this rough-dried material. The fertile portions of the plants are the ends of tertiary branches. Here the branchlets are tetrastichous, but are deflected sharply to the left and especially in sporangial individuals curve partly around the axis, producing a most distinctive strobilar structure. In the axil of each branchlet there is a cushion of tissue on which develop a considerable number of sessile unilocular sporangia. This plant has previously been regarded as native only to Australia and New Zealand, and its discovery on the American continent is of very considerable interest.

## DICTYOTACEAE

SPATOGLOSSUM VELEROAE Taylor. — Peru: Islas Lobos de Afuera, on the shore rocks, *Schmitt* 391E–35, Jan. 17, 1935.

*Reference:* Taylor, 1945, p. 92, pl. 12.

These specimens are smaller than most of the Galápagos plants, reaching a height of but 18 cm.

GLOSSOPHORA KUNTHII (C. Ag.) J. Ag. — Peru: Paita, *Hassler* 1099; *ibid.*, dredged offshore north of the town, *Schmitt* 556A, Oct. 7, 1926. Callao, dredged off Isla San Lorenzo, *Schmitt* 207, Nov. 7, 1926. Chile: Pisagua, Paessler, Herbarium Taylor, 5177, 1902, Antofagasta, *Schmitt* 140 (highly proliferous), Nov. 15, 1926.

*Reference:* Howe, 1914, p. 72, pl. 28.

The proliferous character ascribed to this species is apparently due to the habitual production of minute plantlets from the scattered reproductive organs. Some specimens seen were nearly smooth; others were densely covered with small blades up to 1-2 mm. long, but rarely more.

DICTYOPTERIS COKERI (Howe) Taylor. — Peru: Paita, dredged off-shore north of the town, *Schmitt 556B*, Oct. 7, 1926.

*References:* Howe, 1914, p. 70, pl. 13, figs. 5-9; pl. 27 (as *Neurocarpus Cokeri*). Taylor, 1945, p. 95, pl. 14, fig. 1.

### DESMARESTIACEAE

DESMARESTIA MUNDA Setch. & Gardn. — Peru: Paita, *Hassler 116, 120, 1872*. Bahía Independencia, dredged from 9 meters' depth, *Schmitt 382C-35*, Jan. 14, 1935.

*References:* Setchell and Gardner, 1925, p. 567, pl. 89. Taylor, 1945, p. 108.

This vigorous form, previously known from the North Pacific, has recently been reported by the writer (*loc. cit.*) from moderately deep water off Ecuador; the exact depth from which the present specimens were dredged is not recorded, but at any rate they came from much farther south, in cooler seas.

### LAMINARIACEAE

EISENIA COKERI Howe. — Peru: Paita, *Hassler 126, 1872; ibid.*, Callao, mature sporophylls, *Schmitt 215A*, Nov., 1926; *ibid.*, dredged off Isla San Lorenzo, *Schmitt 214* (mostly juvenile stages), Nov. 7, 1926. Plate IV.

*Reference:* Howe, 1914, p. 55, pl. 14, fig. A; pls. 15-16.

The available material includes plants considerably younger than Howe had, as well as mature blades. The primary blade becomes at least 9 cm. wide and 25 cm. long (dried) before decay at the tip is well established, but by that time the basal pinnae are well over 1 dm. long (incomplete). In a specimen with primary blade 6.5 cm. wide and 16 cm. long (dried) the longest basal pinna was only about 1 cm. The first formed upper pinnae are hardly more than triangular teeth; those produced a little later are sharply upcurved and have a broad base, whereas the ones formed from the meristem when it has begun to function well taper to a

narrow base. There is no suggestion that the plant could at any stage resemble *Laminaria biruncinata* Bory (Bory de St. Vincent, 1827-29, p. 101, pl. 10), to which, however, the writer's *Eisenia galapagensis* (1945, p. 101, pls. 20-22) bears a slightly greater resemblance.

**MACROCYSTIS PYRIFERA** (L.) C. Ag. — Peru: Punta Lomas, Fairchild, Herbarium Taylor, 6998, 1899. Bahía Independencia, dredged from 9 meters' depth, *Schmitt 382B-35*, Jan. 14, 1935.

*Reference:* Setchell and Gardner, 1925, p. 627, pls. 64-65.

The material from Punta Lomas showed both tip and older blades; they had quite evident short teeth. The terminal blade was relatively broad.

**LESSONIA NIGRESCENS** Bory. — Chile: Caldera, juvenile and mature plants, *Hassler 1132*, 1872. Valparaiso, juvenile plants, Harshberger, Herbarium Taylor, 13223, Aug. 16, 1927. Prov. Cautin, *Hollermayer 186K*, 1919.

The younger plants, which are complete and to over 7 dm. tall (dried), show blades 1.5-4.0 cm. wide before being divided, the margins in the wider ones from Valparaiso being smooth to minutely denticulate. Division begins at the basal meristem and produces two apparently equal blades, but one may redivide considerably before the other. The older specimen from Caldera has an extensive heavy branched portion reaching, when dried, a diameter of over 1 5 cm., whereas the blades above hardly reach 5 mm. The Cautin specimen is exceedingly slender, the dried blades only 2-3 mm. wide and rather short; it may represent *L. Suhrii* J. Ag. (Howe, 1914, p. 60).

**MACROCYSTIS INTEGRIFOLIA** Bory. — Chile: Antofagasta, Harshberger, Herbarium Taylor, 13222, 13224, Aug. 19, 1927. Caldera, *Hassler 1133*, 1872.

*References:* Howe, 1914, p. 60, pls. 20, 22. Setchell and Gardner, 1925, p. 628, pl. 62. Smith, 1944, p. 143, pl. 26.

The Caldera material shows excellently the characteristic rhizomatous holdfast in a young specimen. The Antofagasta material is from older plants, and basal parts are lacking. The narrow blades topped long, narrow, downwardly tapering blades. These blades have much longer filiform teeth than those from Caldera, reaching 4 mm., but the terminal blade is relatively narrow, and so the determination seems certain.

## RHODOPHYCEAE

## BANGIACEAE

PORPHYRA KUNTHIANA Kütz. — Peru: Punta Talara, *Schmitt* 166, Aug. 29, 1926. Paita, rocks north of the railroad station, *Schmitt* 544, Oct. 6, 1926. Salaverry, along the shore, *Schmitt* 561, Oct. 18, 1926. Prov. Chancay, *Maldonado* 120C, Feb., 1942. Herreradura, *Schmitt* 177, Oct. 31, 1926. Chile: Caldera, *Hassler* 1131, 1872.

*References:* Kützting, 1869, p. 30, pl. 84. Howe, 1914, p. 74.

The monostromatic blades in this material varied much in size and shape. Some were as narrow as 5 mm., with a length of 19 cm.; others were 1 cm. wide and 21 cm. long; still others were subcordate and 3 cm. broad, 9 cm. long, from which apparently the shape varied to strongly cordate blades as broad as long, or broader, with the greatest width about 9 cm. The thickness in ours is often considerably less than the 60  $\mu$  allowed by Howe, and none of our material reached his greatest dimension, but the characteristic thick outer wall with cells equal or a half taller than broad were distinctive features in all recorded here.

PORPHYRA UMBILICALIS (L.) C. Ag., *prox.* — Plants becoming deeply cordate or subumbilicate, to 10 cm. broad, 13 cm. long, or relatively even wider; monostromatic; thickness to 45–60  $\mu$ , cells in section 1.75–2.5 times as tall as broad; outer and lateral walls moderately thick.

Peru: Salaverry, along the shore, *Schmitt* 562, Oct. 18, 1926. Chile: Valparaíso at Torpederas, in the littoral, where reported eaten by the poorer people and called “luche,” *Schmitt* 250, Jan. 6, 1927. It is unlikely that the natives would distinguish between this and *P. Kunthiana*, for which Valparaíso is the type locality (Howe, 1914, p. 74).

*References:* Taylor, 1937, p. 221, pl. 30, figs. 1–3; 1939, p. 141.

These plants are distinguishable in section by reason of the tall cells which compose the single layer, covered with a matrix relatively much thinner than that in *P. Kunthiana*. This may be what has passed as *P. umbilicalis* from Pacific South American waters, but the cells seem taller than those in the plants of this species familiar to the writer in the North Atlantic.

## GELIDIACEAE

**GELIDIUM CRINALE** (Turn.) J. Ag. — Chile: Bahía Arica, Hassler 4, 1872.

*Reference:* Taylor, 1937, p. 246, pl. 35, figs. 1-3.

This is the terete plant from the southern waters, and it is ordinarily and probably correctly referred to under this name. Accompanying it, and probably mistaken for it, is a similar or an even smaller plant with flat branches. Since this was sterile in the collections available, no identification is offered. It resembled *Pterocladia musciformis* Taylor (1945, p. 159), but the structure was not so clearly identical that these flat plants could be referred to that species.

**GELIDIUM FILICINUM** Bory. — Peru: Paita, Hassler 79, 112 (tetrasporic and cystocarpic), 1872.

*References:* Howe, 1914, p. 97. Taylor, 1945, p. 158.

Howe (*loc. cit.*) had only fragmentary material for his study, but the present material is of good size, reaching a height of 12 cm. His description is accurate in most points. On these larger plants, however, the pinnate branching goes well beyond three orders. The ultimate flat branchlets are sharply rather than obtusely dentate when magnified enough to make this feature visible; there are about 6-10 sharp teeth per millimeter. Howe discusses the relation of his plant to *G. linguatum* J. Ag. (Kützinger, 1868, pl. 65, figs. A-C). The writer finds that the plant Kützinger figured had much more erect, sparingly divided branches and looked quite unlike the present specimens. Plate V, Figure 2.

**Gelidium congestum**, sp. nov. — Plants small, to 4 cm. tall, the terete base briefly flagelliferous, attaching by frequent short irregularly disciform holdfasts; erect axes somewhat clustered, terete at the bottom only, soon expanding to 0.5-1.0 mm. broad, 125-180  $\mu$  thick; axes at first simple, strap-shaped, remaining simple, or very sparingly branched for about 2 cm. in full-grown plants, marginal branching close above, irregularly alternate or in the uppermost parts irregularly cervicorn to digitate, and sometimes sparingly proliferous from the face, the divisions 0.1-0.5 mm. wide, flat to compressed in the smallest parts, entire-margined or appearing irregularly aculeate-toothed by the projection of new branch rudiments; in section the rhizines appearing widely

distributed but chiefly subcortical; surface cells in surface view 3.5–5.0  $\mu$  diam., with thick lateral walls. Plate VI.

Peru: Salaverry, along the shore, *Schmitt* 563, Oct. 18, 1926; *ibid.*, south of the pier, *Schmitt* 570, Oct. 19, 1926 (TYPE).

Plantae usque ad 4 cm. altae, ad basim teretem breviter flagelliferae, hapteris disciformibus adnatae; axibus propinquis, deorsum teretibus, simplicibus vel sparse ramosis, sursum applanatis, minus quam 0.5–1.0 mm. latis, 125–180  $\mu$  crassis, aut dense in marginibus irregulariter alternate ramosis aut ex faciebus irregulariter ramos cervicorniculatos vel digitatos ferentibus aut sparse proliferentibus cum divisionibus ultimis 0.1–0.5 mm. latis, compressis vel subteretibus.

Peru, in loco dicto Salaverry; legit Schmitt, 570, 1926.

### CORALLINACEAE

MELOBESIA MARGINATA Setchell & Foslie. — Peru: Paita, on Gracilaria, *Hassler* 109, p. p., 1872.

References: Setchell and Foslie in Nichols, 1909, p. 350 (as *Lithothamnion marginatum*). Taylor, 1945, p. 176.

CORALLINA CHILENSIS Decaisne. — Peru: Callao, dredged off Isla San Lorenzo, *Schmitt* 215, Nov. 7, 1926; *ibid.*, on Isla San Lorenzo, *Schmitt* 192, Nov. 3, 1926. Chile: Antofagasta, *Schmitt* 136, 139, Nov. 15, 1926. Lota, *Hassler* 1137, 1872. Plate VII.

References: Howe, 1914, p. 178. Taylor, 1945, p. 200, pl. 62.

The writer has already remarked (*loc. cit.*) on the peculiarities of this material and compared it with Mexican and Ecuadorian plants which may belong to the same species. The illustration he gave from Mexican material represents a type with considerably flattened segments; that distributed by Areschoug (Phyc. Extra-Europ. Exsic. 68), a more terete one. At the moment there are no criteria for a specific distinction between these. Howe deals with the taxonomic history of this plant, which the present writer feels it is necessary to distinguish from *C. officinalis* and so uses the name *C. chilensis*, in spite of its somewhat uncertain application.

CORALLINA OFFICINALIS L. — Peru: Salaverry, *Schmitt* 171, Oct. 19, 1926. Bahía Independencia, from the shore on the east side, *Schmitt* 380–35, Jan. 14, 1935.



*References:* Howe, 1914, p. 179 (as *C. officinalis* var. *collabens*). Taylor, 1939, p. 143.

This may well be the same plant as that designated var. *collabens* by Howe (*loc. cit.*), but, if so, the writer sees no advantage in the varietal designation. In the present material the marginate character is not evident, and calcification is complete. It would be hard, if not impossible, to distinguish this from some shallow-water New England material, or some the writer has reported from southern Chile.

### GRATELOUPIACEAE

**Halymenia foliacea**, sp. nov. — Plant foliaceous, to 11 dm. tall, moderately thin, dark, somewhat brownish red (from preserved material); the stipe very small and slender, the blade lanceolate, or the base from cuneate later to transverse or subcordate, the margins entire to obscurely crenate, the acute apex simple to 1-3 times forked; occasionally marginally proliferous near the base; thickness (soaked up) to 120-215  $\mu$ ; medulla of numerous filaments about 4-8  $\mu$  diam., occasionally near the cortex with very inconspicuous stellate cells 15-22  $\mu$  diam., with 4-6 attaching filaments not visible through the cortex; subcortex loose, of 2-3 layers of rounded cells about 8-20  $\mu$  diam., the outer cortex of a close layer of rounded cells in section 1.5-2.0 times as tall as broad, 6-8  $\mu$  diam., in surface view appearing irregularly rounded, 6-10  $\mu$  diam., somewhat grouped in twos or fours, the intercellular and the outer walls moderately thick; spermatangia borne 2-3 on a cortical cell, cut off by oblique walls, 4-5  $\mu$  diam.; cystocarps very numerous, evenly distributed, about 0.5 mm. diam. Plate VIII, Fig. 2.

Peru: Callao, dredged off Isla San Lorenzo, *Schmitt* 213 (spermatangial), Nov. 7, 1926; *ibid.*, from 5.4 meters' depth, *Schmitt* 364D-35 (cystocarpic), Jan. 1, 1935 (TYPE). Islas Chinchas, dredged from 14 meters' depth, *Schmitt* 386A-35, Jan. 15, 1935.

Plantae foliaceae, grandiores 11 dm. altae, stipite parvo; lamina lanceolata basi cuneata vel subcordata, margine integra plana vel vix crenata, apice simplici vel furcata, crassitudine plantae made-factae plerumque 120-215  $\mu$  in plantis grandioribus; medulla ex

filamentis numerosis constante raro prope corticem cellulis stellatis praedita; cystocarpiis numerosis, acquabilibus, ca. 0.5 mm. diam.

Peru, in porto dicto Callao; legit Schmitt, 364D-35, 1935.

From Howe's Peruvian *H. tenera* (1914, p. 159) this species differs in its more elongate shape, greater thickness and loose inner medulla. One should note, however, that the sections frequently resisted expansion from the dried state, and one might readily get the false impression of a compact medulla. It is larger and thicker than any species described from Ecuador by the author. It is thinner and has a thinner surface jelly than *H. abyssicola*, described from a fragment by Dawson (1944, p. 278).

GRATELOUPIA CUTLERIAE Kütz. — Peru: Paita, Hassler 122, 1872.

Reference: Howe, 1914, p. 166, pls. 59-60 (f. *procera*).

GRATELOUPIA DENTICULATA Mont. — Fragments of the upper parts of plants measuring to 30 cm. long, 27 mm. broad (dried), branching to four degrees, the segments strap-shaped, tapering upward to sharp ends, fleshy, blackish brown as dried; margins closely beset with simple or 2-3-forked aculei to 2 mm. long; surface abundantly beset with slightly shorter aculei; sections about 650  $\mu$  thick, the inner medulla of moderately close interweaving but chiefly longitudinal filaments 4-9  $\mu$  diam.; the outer medulla 110  $\mu$  thick, of anticlinal branching cell series 10-12 cells long, moderately easily dissociated by pressure, the inner cells nearly isodiametric or radially a little elongated, about 10  $\times$  15  $\mu$  diam., laterally not contiguous, the outermost cells about 6  $\times$  8  $\mu$  diam., a little subquadrate-compressed laterally with thin walls; externally the jelly only moderately thick. Plate IX, Figure 2.

Peru: Paita, Hassler 127, 1872, det. Setchell and Gardner.

References: Montagne, 1846, p. 145. Howe, 1914, p. 170.

GRATELOUPIA DORYPHORA (Mont.) Howe. — Peru: Callao, Maldonado 305, June, 1942, det. Setchell.

References: Montagne, 1839, p. 21 (as *Halymenia doryphora*). Howe, 1914, p. 169, fig. 43.

Fragments only in the piece seen by the author, and very narrow at that, indeed in part sublinear. The histology seemed to agree, however, with Howe's specifications.

GRATELOUPIA SCHIZOPHYLLA Kütz. — Peru: Salaverry, along the shore, Schmitt 560, Oct. 18, 1926; *ibid.*, on wreckage, Schmitt 576,

Oct. 21, 1926. Callao, from Isla San Lorenzo, *Schmitt* 186, Nov. 1, 1926.

*References:* Howe, 1914, p. 168, pls. 61–62. Kützing, 1867, p. 11, pl. 36.

**PRIONITIS DECIPIENS** (Mont.) J. Ag. — Peru: Punta Talara, *Schmitt* 168, Aug. 29, 1926, det. Setchell and Gardner. Paita, dredged from offshore north of the town, *Schmitt* 552, Oct. 7, 1926.

*Reference:* Howe, 1914, p. 174, pl. 64.

### SEBDENIACEAE

**Sebdenia** (?) **chichensis**, sp. nov. — Plants foliaceous, to 21 cm. tall, the texture membranous, when dried subnitent, adhering poorly to paper except in the youngest portions; from a small holdfast and short slender stalk gradually cuneate-expanded to a blade which reaches a width of 2.5–4.5 cm., branching 1–3 times subdichotomously or palmately from the margins, the tips broadly rounded, minutely retuse at the growing point, below alternately expanded and contracted to as little as one third of the width in the adjacent broad portions, the margins otherwise obscurely crenate and crisped; thickness to 75  $\mu$  (perhaps incompletely expanded); the cuticle firm, to 4–5  $\mu$  thick; cortex irregular, about 10–15  $\mu$  thick of 1–2 layers, in surface view the cells 4–15  $\mu$  diam., angular and with firm walls between, in section rounded, 5–9  $\mu$  diam.; subcortical layer of scattered colorless rounded cells but little larger; medulla (perhaps poorly expanded) thin, of moderately close-placed filaments, some thin-walled, but numerous others markedly refractive though obscure when seen in surface view, anatomosing but not clearly forming stellate ganglionic junctures; reproduction not seen. Plate X, Figure 1.

Peru: Islas Chinchas, *Schmitt* 390D–35, Jan. 15, 1935.

Plantae foliaceae longitudine usque ad 21 cm., membranosae; haptero parvo; stipite brevi gracili sursum gradatim applanato; lamina 2.5–4.5 cm. lata, semel, bis vel ter ex margine subdichotome vel palmatim ramosa; ramis apice late rotundatis et minute retusis, deorsum longo intervallo repetiter angustatis et expansis, crassitudine 75  $\mu$ ; medulla constante ex filamentis modice densis interdum refractivis, anastomosantibus sed non figuras stellatas formantibus.

Peru, in insulis dictis Islas Chinchas; legit Schmitt, 390D-35, Jan. 15, 1935.

In general structural features these plants resemble 392A-35, but are thinner and with a different cortex, less medulla, and less evident refractive filaments. It is difficult to imagine the very striking form of the thallus as an immaterial variant of any of the other known Peruvian or Chilean *Sebdeniae* or *Halymeniae*.

***Sebdenia* (?) *afuerensis*, sp. nov.** — Plant subfoliaceous, to 18 cm. tall, the texture firmly membranous, when dried hardly nitent, adhering poorly to paper; from a small holdfast developing a compressed axis which may divide once or twice successively, above strap-shaped, expanding gradually to 1-2 cm. in width and branching 2-3 times successively irregularly to subdichotomously from the margin, somewhat narrowed toward the rounded tips, the margin irregular; thickness to 130  $\mu$  in younger parts, to 140  $\mu$  in the older blades; the cuticle not specially thick; cortex irregular, the cells round to oval, usually in one layer, in section 4-6  $\mu$  deep and slightly narrower, in surface view round to oval, 3-7  $\mu$  diam., the lateral walls refractive and relatively thick, to 1.5-3.0  $\mu$ ; subcortical layer 12-15  $\mu$  thick, of 1-2 layers of rounded cells 7  $\mu$  diam. or transversely oval, to 7  $\times$  15  $\mu$  diam.; medulla not sharply delimited in older parts, more clearly so in the younger, in which it consists of many slender filaments and, interspersed, numerous others without evident lumen, to 7  $\mu$  diam. and much more refractive, from the surface seen to be obviously anastomosed with enlarged junctures reaching 50-70  $\mu$  diam., few to several filaments radiating from each; in older parts the ordinary filaments 3-5  $\mu$  diam. with thick obviously coalescent walls, the refractive filaments somewhat larger; reproduction not seen. Plate X, Figure 2.

Peru: Islas Lobos de Afuera, dredged from 36-40 meters' depth in North Bay, *Schmitt* 392A-35, Jan. 17, 1935 (TYPE).

Planta subfoliacea, altitudine minus quam 18 cm., firme membranacea; hapteris parvis; axe ad basim tereti, semel vel bis diviso, divisionibus deorsum liguliformibus et gradatim expansis in laminas 1-2 cm. latas, usque ad 140  $\mu$  crassas, irregulariter ex margine bis vel ter ramificantes, apicibus angustatis rotundatisque; medulla constante ex filamentis specierum duarum, videlicet, ordinariis 3-5  $\mu$  diametientibus, aliisque valde lucem

refringentibus, diam. 7  $\mu$ , ex superficie obvie anastomosantibus ganglia 50–70  $\mu$  diam. formantibus; in partibus vetustioribus frondis filamentis ordinariis incrassatis et inter se coalescentibus.

Peru, in insulis dictis Islas Lobos de Afuera; legit Schmitt, 392A–35, 1935.

These plants are very suggestive of *Sebdenia limensis* (Sond.) Howe (1914, p. 160; Kützing, 1866, pl. 79, as *Halymenia limensis*), but are much more branched and with narrower segments. From *S. limensis* their much wider medulla also probably distinguishes these plants. Unfortunately, they are nearly covered with bryozoa, and so the exact habit is obscured. A certain similarity to *Halymenia leiphacnia* Montagne (1839, pl. 6, fig. 2) caused that species to be considered, but it is more flabellately branched; we do not know its structure. Howe's plant (1914, p. 163, pl. 58) does not seem to have a stalklike portion below and is broader and markedly marginally proliferous.

SEBDENIA LAPATHIFOLIA (Kütz.) Howe. — Peru: Paita, Hassler 121 (cystocarpic), 1872.

References: Kützing, 1866, pl. 99 (as *Halymenia lapathifolia*). Howe, 1914, p. 162.

The plant assigned to this species was about 45 cm. long, 7.5 cm. wide. The base was very slender, sharply cuneate-expanded, and subreniform, thence gradually lanceolate. When the sections were fully restored to shape the medulla was loose, and the thickness reached 250  $\mu$ .

### CALLYMENIACEAE

CALLOPHYLLIS VARIEGATA (Bory) Kütz. — Peru: Bahía Independencia, dredged from 9 meters' depth east of Isla Vieja, Schmitt 371C–35, Jan. 12, 1935. Chile: Isla Chiloë, at San Pedro, Hassler 1135.

Reference: Howe, 1914, p. 119.

### SOLIERIACEAE

AGARDHIELLA TENERA (J. Ag.) Schmitz. — Peru: Paita, Hassler 123 (cystocarpic), 1872. Callao, at Isla San Lorenzo, Schmitt 195, Nov. 3, 1926. Bahía Independencia, dredged from 9 meters' depth, Schmitt 382A–35, Jan. 14, 1935.

*References:* Howe, 1914, p. 119, pl. 47. Taylor, 1937, p. 286, pl. 38, fig. 4; pl. 41, fig. 2; pl. 59, fig. 9; 1945, p. 222.

### PLOCAMIACEAE

*PLOCAMIUM COCCINEUM* (Huds.) Lyngb. — Chile: Tocopilla, *Schmitt 156*, Nov. 15, 1926.

*Reference:* Kylin and Skottsberg, 1919, p. 30.

*PLOCAMIUM SECUNDATUM* Kütz. — Chile: Caldera, *Hassler 1125*, 1872.

*References:* Kylin and Skottsberg, 1919, p. 31, fig. 16. Taylor, 1939, p. 144.

### GRACILARIACEAE

*GRACILARIA LEMANAEFORMIS* (Bory) Weber-van Bosse. — Peru: Paíta, *Hassler 110* (cystocarpic), 1872.

*References:* Howe, 1914, p. 128, pl. 52 (as *Cordylecladia lemanaeformis*); Weber-van Bosse, 1913-28, p. 435.

*GRACILARIA PERUANA* Picc. & Grun. — Peru: Paíta, *Hassler 105*, 129, 1872 (det. Howe); *ibid.*, *Schmitt 165*, Oct. 6, 1926; *ibid.*, rocks north of railroad station, *Schmitt 543*, Oct. 6, 1926; *ibid.*, dredged offshore, *Schmitt 551*, Oct. 7, 1926.

*References:* Piccone, 1886, p. 70. Howe, 1911, p. 505; 1914, p. 123.

### PHYLLOPHORACEAE

*AHNFELTIA DURVILLAEI* (Bory) J. Ag. — Peru: Punta Talara, *Schmitt 167*, Aug. 29, 1926. Paíta, dredged just north of the town, *Schmitt*, Oct. 7, 1926. Islas Lobos de Afuera, *Schmitt 391B-35*, Jan. 17, 1935. Salaverry, *Schmitt 167B*, Oct. 18, 1926. Islas Chinchas, at North Chíncha Island, K. P. Schmidt, Nov. 1, 1939. Prov. Chancay, *Maldonado 120A*, Feb., 1942.

*Reference:* Howe, 1914, p. 110, pls. 44, 46.

*AHNFELTIA SETACEA* (Kütz.) Schmitz. — Chile: Corral, Herbarium Taylor 4746 (originally as *Gymnogongrus furcellatus*), det. Setchell and Gardner.

*Reference:* Kützing, 1869, p. 15, pl. 67, fig. 2.

*GYMNOGONGRUS DISCIPLINALIS* (Bory) J. Ag. — Peru: Salaverry, along the shore, *Schmitt 565*, Oct. 18, 1926; *ibid.*, south of the pier, *Schmitt 568*, Oct. 19, 1926. Callao, from Isla San Lorenzo,

190 (cystocarpic), 194, Nov. 1, 3, 1926. All det. Setchell and Gardner.

*Reference:* Howe, 1914, p. 109, pl. 43.

GYMNOGONGRUS FURCELLATUS (C. Ag.) J. Ag. — Peru: Paita, *Hassler* 89, 1872, det. Setchell and Gardner. Callao, on Isla San Lorenzo, *Schmitt* 191, Nov. 1, 1926. Chile: Isla Chiloë, Herbarium Taylor 4748 (originally as *Chondrus violaceus*), det. Setchell and Gardner.

*Reference:* Howe, 1914, p. 107, pl. 42.

### GIGARTINACEAE

GIGARTINA CHAMISSOI (C. Ag.) J. Ag. — Peru: Paita, *Hassler* 86, 88, 108, 1872, det. Setchell and Gardner.

*References:* Pilger, 1908, p. 180. Howe, 1914, p. 99. Collins, 1915, p. 92.

GIGARTINA CHAUVINII (Bory) J. Ag. — Peru: Paita, dredged offshore north of the town, *Schmitt* 554, Oct. 7, 1926; *ibid.*, off rocks north of the railroad station, *Schmitt* 548, Oct. 6, 1926. Salaverry, on wreckage, *Schmitt* 573, Oct. 21, 1926. All det. Setchell and Gardner, and all at least in part cystocarpic. Callao, dredged off Isla San Lorenzo from 5 meters' depth, *Schmitt* 364E-35, 382D-35, Jan. 10, 14, 1935; *ibid.*, *Schmitt* 211, Nov. 7, 1926, det. as a depauperate individual by Setchell and Gardner; *ibid.*, *Maldonado* 301, June, 1942, det. Setchell.

*References:* Bory de St. Vincent, 1827-29, p. 165, pl. 20. Howe, 1914, p. 101, pl. 38. Setchell and Gardner, 1933, p. 266.

Setchell and Gardner considered that 548, 554, and 573 were *Sphaerococcus Chauvinii* var. *angusta* Bory (1827, pl. 20, fig. 3), and perhaps they are, but their excessively soft texture was due to disintegration in the preservative.

GIGARTINA GLOMERATA Howe. — Peru: Herradura, *Vargas* 1246, Oct. 25, 1938.

*Reference:* Howe, 1914, p. 103, pl. 39.

GIGARTINA LESSONII (Bory) J. Ag. — Peru: Paita, *Hassler* 117, 1872. Callao, small specimens from Isla San Lorenzo, *Schmitt* 187, 196, Nov. 1, 3, 1926, det. Setchell and Gardner. Prov. Chancai, *Maldonado* 120B, Feb., 1942. Chile: Arica, *Hassler* 5, 1872. : San Vicente, *Hassler* 1136, det. Setchell and Gardner.

*References:* Bory de St. Vincent 1827–29, p. 169 (as *Sphaerococcus Lessonii*). Howe, 1914, p. 100, pl. 37.

**Gigartina paitensis**, sp. nov. — Plant to 0.5–1.0 dm. tall, bushy, probably of rather soft fleshy consistency, the holdfast small, cushion-shaped, the axis terete and slender at the base, soon enlarging to 1.5–2.5 mm. diam., terete or compressed, branching alternately and somewhat bilaterally, with several secondary percurrent axes, in the lesser divisions narrowly pyramidal, the smaller branches tapering and the branchlets rather abruptly acute, even aculeate; reproduction not seen. Plate XI.

Peru: Paita, *Hassler 111*, 1872.

Plantae fruticulosae, 0.5–1.0 dm. altae, haptero parvo; axe ad basim tereti, gracili mox crescente ad diametrum 1.5–2.5 mm., tereti vel compresso, alternate subbilateraliter ramoso; ramis secundariis paucis percurrentibus; ramis minoribus angustatis et ultimis breviter acutis.

Peru, in loco dicto Paita; legit "Hassler Expedition," 111, 1872.

These plants in their looser aspects remarkably resemble *Agardhiella tenera* when dried, but the gigartinaceous structure, with a filamentous medulla in which there are coarser and slenderer elements merging into a cortex of radial branching cell rows, is distinctive. The most obvious comparison is with *G. glomerata* Howe (1914, p. 103, pl. 39; pl. 41, figs. 1–11). Our plant is much larger and less densely branched, even in the most crowded example, and the branchlets are more acutely tapered.

**IRIDOPHYCUS BORYANUM** Setchell & Gardner. — Chile: Lota, *Hassler 1140*, 1872, det. Setchell.

*References:* Bory de St. Vincent, 1827–29, pl. 11, fig. 1 A–C (as *Iridaea laminarioides*). Setchell and Gardner, 1937, p. 202.

**IRIDOPHYCUS CILIATUS** (Kützinger) Setchell & Gardner. — Chile: Isla Chiloë, from San Carlos (old specimens originally as *Iridaea ciliata*), Herbarium Taylor 4757, tetrasporic and cystocarpic, det. Setchell and Gardner. Plate IX, Figure 1.

*References:* Kützinger, 1867, p. 4, pl. 10. Setchell and Gardner, 1937, p. 220.

**IRIDOPHYCUS LAMINARIOIDES** (Bory) Setchell & Gardner. — Chile: Lota, *Hassler 1141*, 1872, det. Gardner.

*References:* Bory de St. Vincent, 1827–29, pl. 11, fig. 1 I D (as *Iridaea laminarioides*). Setchell and Gardner, 1937, p. 206.



## RHODYMENIACEAE

**Dendrymenia Corallina** (Bory), comb. nov. — Peru: Salaverry, on wreckage off beach north of pier at station 17, *Schmitt* 571, Oct. 21, 1926. Islas Chinchas, dredged from 14 meters' depth, *Schmitt* 386B-35, Jan. 15, 1935. Bahía Independencia, dredged at 9 meters' depth, *Schmitt* 382D-35, Jan. 14, 1935. Plate VIII, Figure 1.

*References:* Bory de St. Vincent, 1827-29, p. 175, pl. 16 (as *Sphaerococcus Corallinus*). Howe, 1914, p. 124 p. p., probably pl. 51, but not pl. 50 (as *Rhodymenia Corallina*). Dawson, 1941, p. 148, pl. 21, figs. 28-29 (as *Rhodymenia Corallina*).

Dawson (*loc. cit.*) is probably correct in considering this plant closely related to *Dendrymenia flabellifolia* (Bory) Skottsb., and if the genus *Dendrymenia* is to be maintained, the new combination must be made for the name. These specimens, some of relatively young though luxuriant plants, show but a short main axis. In others the erect axes reach two decimeters in height. The foliar divisions, however, are not so distinct as in *D. flabellifolia*, and the aspect is somewhat intermediate between Bory's plates 16 and 17, whereas Howe's *R. flabellifolia* and those plants which the writer ascribes to that species are much more congested than even Bory's plate 17 shows his plant to have been. Howe's *R. Corallina* in his plate 51 appears to the writer to have an erect axis.

## CERAMIACEAE

**CERAMIUM RUBRUM** (Huds.) C. Ag. — Chile: Isla Chiloë, at San Pedro, *Hassler* 1134, 1872.

*References:* Howe, 1914, p. 156. Taylor, 1937, p. 340; 1939, p. 152.

This species has often been recorded from South America, and the writer has had considerable material of it from the Strait of Magellan, which certainly is not the segregate *C. pacificum* (Collins) Kylin. In the warmer Atlantic waters *C. rubrum* appears occasionally in a small form, but we have no report of it from the tropical American Pacific shores, nor of *C. pacificum*. The material listed above has numerous lower lateral branchlets; in this it somewhat resembles *C. pacificum*, but no more than many

North Atlantic specimens do, and it lacks the characteristic regular corymbose habit of perfect *C. pacificum*.

*CENTROCERAS CLAVULATUM* (C. Ag.) Mont. — Peru: Salaverry, along the shore, *Schmitt* 564, Oct. 18, 1926. Chile: Arica, a very small amount mixed with *Gelidium crinale*, *Hassler* 4B, 1872.

*References:* Howe, 1914, p. 158. Taylor, 1928, p. 189, pl. 28, figs. 6-7; 1945, p. 272.

*GRIFFITHSIA CHILENSIS* Mont. — Peru: Paíta, on Corallina, *Hassler* 92, 1872. Callao, dredged off Isla San Lorenzo, *Schmitt* 206, Nov. 7, 1926. Chile: Antofagasta, on the holdfasts of *Halopteris*, scarce, *H. H. Bartlett* 19022C (polysporic), Sept. 9, 1942. Plate I, Figure 2.

*References:* Kützinger, 1862, p. 7, pl. 21, figs. D-F. Howe, 1914, p. 149.

All the Peruvian material was sterile, like that collected by Coker, but is probably correctly attributed to this species. The Paíta plant is short and stout, probably from shallow water, whereas the dredged Callao specimen is slenderer and laxer.

The Chilean specimens consisted of a very few filaments, but proved exceedingly important, for they bore sporangia, and no kind of fruit has hitherto been known in this species. There is no reason to suspect that they are anything else than Montagne's *G. chilensis*. Unilaterally on the distal ends of two or three somewhat shortened upper but not uppermost segments there occur stout lateral branches which sharply divide and redivide, producing a dense cluster of branchlets, the stout end cells of which are strongly incurved, whereas on the cells below these large numbers of sporangia occur. This structure corresponds to that of the subgenus *Eugriffithsia* of Feldmann-Mazoyer (1940, p. 407), so far as can be determined from the very scanty dried material, though with so limited material it was not possible to work out the exact cell sequence and position of the sporangia. This is apparently the first American record of this subgenus. However, another remarkable feature appears in that these sporangia become polysporic; there is no distinct four-celled stage, and though what appear to be fairly mature sporangia with six spores were seen, most that were half grown or larger quite clearly had eight spores, and no larger number was certainly seen. These sporangia measured 85-125  $\mu$ , rarely to 170  $\mu$  diam. Poly-

sporangia apparently have not previously been reported in *Griffithsia*.

**PLATYTHAMNION ORBIGNIANUM** (Mont.) Howe. — Peru: Callao, dredged off Isla San Lorenzo, *Schmitt 212*, Nov. 7, 1926. Bahía Independencia, dredged from 13 meters' depth, *Schmitt 376B-35*, Jan. 13, 1935.

*References:* Montagne, in D'Orbigny, 1839, p. 7, pl. 7, fig. 4. Howe, 1914, p. 154.

The cells of the oldest axes were subcylindrical, but those of intermediate size were considerably inflated above the middle, and here the lateral branchlets were attached. The septa at the ends were considerably narrower. Howe accepts Montagne's description of the cells as of "hourglass form," but the comparison is not good, for the cells are not all contracted at the middle, but, rather, inflated. The material was abundant and well preserved, though sterile.

**PLEONOSPORIUM VENUSTISSIMUM** (Mont.) De Toni. — Peru: Paita, *Hassler 81* (with sporangia). Callao, dredged off Isla San Lorenzo, *Schmitt 202*, Nov. 7, 1926.

*References:* Kützinger, 1862, pl. 1, figs. A-B. Howe, 1914, p. 150.

### DELESSERIACEAE

**ACROSORIUM** sp.? — Plants decumbent and attached below, mostly free above, to 5-7 cm. tall (or more?), irregularly palmately lobed, the lobes short and about 3-5 mm. wide, or to 3 cm. long and 3-7 mm. wide, simple or sparingly divided; thallus to three cells thick and 65  $\mu$  below, nearer the holdfast increasing in some to 130  $\mu$ , one cell thick above except at the veins, the cells of the major portion 32-60, rarely to 80  $\mu$  broad, 32-75, occasionally to 100-120  $\mu$  long; microscopic veins with a lens evident to near the tip, anastomosing, 32-64  $\mu$  broad, one or sometimes two cells wide, the cells 65-160  $\mu$  long; reproductive stages not seen.

Peru: Callao, dredged off Isla San Lorenzo, *Schmitt 208*, Nov. 7, 1926. Bahía Independencia, dredged east of Isla Vieja, *Schmitt 372A-35*, Jan. 12, 1935.

**ACROSORIUM UNCINATUM** (J. Ag.) Kylin. — Chile: Antofagasta, on the basal parts of *Halopteris*, *Bartlett 19021* (tetrasporic), Sept. 9, 1942.

*References:* Taylor, 1930, p. 632, pl. 39 (as *Nitophyllum uncinatum* (Turn.) J. Ag. Okamura, 1936, p. 786, fig. 379.

These were very minute specimens — only one or two centimeters high. The characteristic branching was recognizable only in the largest, the others appearing subdichotomous, and the hooked tips were not frequent. On several blades tetrasporangial sori were found in the center of terminal segments, or, rarely, were apparently left behind by further growth of the tip.

**Cryptopleura cryptoneuron** (Mont.), comb. nov. — Peru: Paita, Hassler 87\* (spermatangial), 113 (tetrasporic). Callao, dredged off Isla San Lorenzo, Schmitt 209 (tetrasporic and spermatangial), Nov. 7, 1926. Plate XII.

*References:* Montagne, 1839, p. 33 (as *Aglaophyllum cryptoneuron*). Howe, 1914, p. 131, pl. 54 (as *Nitophyllum cryptoneuron*). Kylin, 1924, p. 81 (as *Hymenena cryptoneuron*).

The Hassler specimens in particular closely resemble Howe's figure (*loc. cit.*). The specimen in the herbarium of the New York Botanical Garden is well shown in this illustration; it is of a somewhat smaller plant than those here reported. Except for 465, from Pisco, the specimens on the two pertinent sheets at the New York Botanical Garden appear to belong to another genus, and so probably do Schmitt's 208 and 372A-35. The pale spots on the blades of Howe's plant are probably artifacts, not spermatangial sori; similar and sterile areas were seen in Delesseriaceae in the Schmitt collections. The plants show minute anastomosing veinlets barely visible to the unaided eye 1-3 cm. below the tips. The spermatangial and sporangial sori formed marginal bands, or rounded sori in marginal crisped lobules. In 113 marginal lobules were lacking, and the blades were narrower than in 209, where they reached two centimeters in width above a fork in the lower part of the plant. Plants of this collection in the lowest portions near the holdfasts reached 355  $\mu$  in thickness, with the cuticle 5-10  $\mu$  thick, the one central layer of cells columnar and 125  $\mu$  thick, and with 2-3 surface layers of flattened cells on each side. In the upper part, where it was only 65-115  $\mu$  thick, there was only one cell layer, except that the veins were of three layers.

**Cryptopleura peruviana**, sp. nov. — Plants to 3 dm. tall, foliaceous, dull reddish purple; axes below somewhat thickened, stalklike, irregularly proliferating, above cuneate-expanded to broad ir-

regularly cleft blades, the divisions 1.0–2.5 cm. wide, distally narrower, some divisions, especially the sporangial ones, being ligulate, the apices rounded obtuse; margins somewhat irregular, essentially entire above, but in the central part often ruffled or bearing small lobules; surface dull, marked by numerous inconspicuous anastomosing veins; spermatangia and tetrasporangia on the marginal ruffles or lobules. Plate XIII, Figure 2.

Peru: Païta, *Hassler* 128 (spermatangial and tetrasporangial), 1872 (TYPE).

Plantae usque ad 3 dm. altae, foliaceae, colore atriuscule vinaceae, superficie opaca haud nitida; axe tenui, incrassato, deorsum cuneate dilatato in laminas latas irregulariter fissas; divisionibus 1.0–2.5 cm. latas, sursum angustatis et aequaliter ligulatis, apicibus rotunde obtusis, margine irregularibus crispatisque vel in parte superiore integris cum venulis numerosis inconspicuis anastomosantibus ornatis; spermatangiis et tetrasporangiis in margine crispata vel marginis lobulis positis.

Peru, in loco dicto Païta; legit "Hassler Expedition," 128, 1872.

The apical cells are obscure and divide obliquely and laterally; apparently intercalary divisions occur frequently. The thallus is one cell thick between the veins above, but because of the close approximation of the vein rudiments it generally appears two or more cells thick from the surface.

**Hemineura Hassleri**, sp. nov. — Plants to 15 cm. tall or more, dull red in color (as dried), base small, lobed, axis moderately stout and subterete below, several times branched, above flattened and denuded, expanding into the linear oblanceolate blades, which have evident midribs and irregular, rather coarsely dentate margins, alternately marginally freely branching; branches to 8–12 mm. wide (dried), moderately thin, with an evident midrib but without evident lateral veins, the margin irregularly dentate; reproduction in irregular ovate marginal lobules 0.5–2.5 mm. long, the tetrasporangia in large sori, one on each side of the midline of the lobule; the cystocarps 1–2, on the midline of the lobule or a subdivision of it. Plate XIII, Figure 1.

Peru: Païta, *Hassler* 118 (tetrasporic, cystocarpic), 1872 (TYPE).

Plantae altitudine usque ad 11 cm., axe deorsum denudato, sur-

sum lineari-oblanœolato, cum margine tenui grosse dentato et veno conspicuo, alternate ex margine dense ramoso; ramis 8-12 mm. latis vena mediana praeditis sed absque venulis lateralibus; tetrasporangiis in soris magnis utrinque secus vena mediana lobulosum irregularium ovatorum marginalium 0.5-2.5 mm. longorum; cystocarpiis 1 vel 2, in linea media lobulorum primariorum vel secundariorum.

Peru, in loco dicto Paita; legit "Hassler Expedition," 118, 1872.

The apical cells of these plants divided transversely by a lunate segment, and the primary axial rows of cells did not subdivide transversely, although eventually the secondary axes did. The tertiary axes only in part reached the margin and ramified chiefly on the lower side. The thallus developed one large-celled medullary layer and a single cortical layer on each face; the cells soon without definite order as viewed from the surface. The axis in section becomes 2-5 cells thick in the middle portion of the plant, but the cells are in no definite arrangement in section; there are only a few somewhat smaller cells among them near the center, but there is no abundance of rhizoidal cells. The midribs of the side branches and marginal lobules do not traverse the chief blades as distinct structures. These plants are much less branched above than *H. frondosa*, are smaller, duller, and more irregular than *H. Schmitziana*, and are distinguished from *H. Howellii* Taylor from Ecuador by the fact that the tetrasporic lobules are hardly if at all contracted at the base, and are certainly not stipitate, whereas the whole texture is much thinner.

### RHODOMELACEAE

**Laurencia paitensis**, sp. nov. — Plants to 12 cm. tall or more, loosely branched, the axis subterete and to 3 mm. diam., tapering toward the base and the top of the plant; primary branching moderate at intervals of 1-2 cm., the branches like the axis; minor branching at intervals of 0.5-1.0 cm., these branchlets beset with a few very short truncate ultimate branchlets; medulla in section of very large thin-walled cells; cortex of cells as broad as deep or broader, and in surface view 22-30  $\mu$  wide, 2-5 times as long and somewhat tapering to the ends; tetrasporangia in the ultimate branchlets or

about their bases; sexual reproduction not seen. Plate V, Figure 1.

Peru: Paita, *Hassler 114* (tetrasporic), 1872 (TYPE).

Plantae altitudine usque ad 12 cm., laxe ramosae, subteretes, minus quam 3 mm. crassae, ex parte media utrinque angustatae; ramis primariis (majoribus) modice densis inter se 1–2 cm. distantibus; minore ramificatione densiore cum ramis inter se 0.5–1.0 cm. distantibus et singulatim paucis brevibus truncatis ramulis ultimis praeditis; tetrasporangiis aut in ramulis ultimis sitis vel circum eorum basim.

Peru, in loco dicto Paita; legit "Hassler Expedition" 114, 1872.

This plant is similar to *L. crispa* Hollenberg (Smith, 1944, p. 378). The gross habit is quite different, for we have no evidence that the plant is tussock-forming; its growth appears to be loose and free. The minor branch and branchlet forms are similar, and the structure also is similar, though the surface cells, while nearly isodiametric in section, are in surface view broader and elongate.

**POLYSIPHONIA SUBTILISSIMA** Mont., *prox.* — Plants repent below, to at least 5 cm. tall in the erect portion, freely branched, the erect branches like the axis, the tips slightly corymbose; apices without trichoblasts, the apical cells evident; axis with four pericentral cells, ecorticate, to 100–125  $\mu$  diam. below, but about 50  $\mu$  diam. in the smaller branches, the segments 1–2 diameters long; tetrasporangia single in the upper segments, not markedly inflating them, and forming long series.

Peru: Islas Chinchas, dredged from a sandy bottom at 14–18 meters' depth near the northwest corner of Mid Island, *Schmitt 389A–35*, Jan. 15, 1935.

*Reference:* Taylor, 1937, p. 365.

These plants are a bit coarser than New England *P. subtilissima*, but in warmer waters there are other tetrasiphonous plants ascribed to this species which are likewise coarser. Perhaps there are several species with the same habit. Until they can be segregated this seems to be a suitable name for these specimens.

**POLYSIPHONIA PANICULATA** Mont. — Peru: Salaverry, on wreckage, *Schmitt 572*, Oct. 21, 1926. Paita, *Hassler 82, 100*; *ibid.*, *Schmitt 572B*, Oct. 6, 1926. Callao, at Isla San Lorenzo, *Schmitt 188*,

Nov. 1, 1926. Chile: Arica, *Hassler 15-18*. Det. G. J. Hollenberg. Plate II, Figure 2.

*Reference:* Howe, 1914, p. 142.

**PTEROSIPHONIA PENNATA** (Roth) Falk. — Peru: Salaverry, on wreckage, *Schmitt 575* (tetrasporic), Oct. 21, 1926. Callao, from Isla San Lorenzo, *Schmitt 193*, Nov. 3, 1926. Plate XIV, Figure 2.

This material reached a height of about 6 cm.; in axis, and especially in branchlets it seemed stouter than a French specimen with which it was compared, and very much stouter and with relatively shorter branchlets than material from California (*Gardner 2524*) and Japan; nevertheless, no suitable characters were found to differentiate it.

**PTEROSIPHONIA DENDROIDEA** (Mont.) Falk. — Peru: Paita, *Hassler 78, 98, 1872*; *ibid.*, fragments dredged north of the town, *Schmitt 558*, Oct. 7, 1926. Callao, dredged off Isla San Lorenzo, *Schmitt 210*, Nov. 7, 1926.

*References:* Howe, 1914, p. 144. Taylor, 1945, p. 304, pl. 96, fig. 2.

**STREBLOCLADIA CAMPTOCLADA** (Mont.) Falk. — Peru: Callao, dredged off Isla San Lorenzo, *Schmitt 201*, Nov. 7, 1926. Bahía Independencia, dredged from 9 meters' depth east of Isla Vieja, *Schmitt 371D-35*, Jan. 12, 1935. Plate XIV, Figure 1.

*Reference:* Howe, 1914, p. 146.

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## EXPLANATION OF PLATE I

- FIG. 1. *Halopteris hordacea*. Branches with strobilus-like sporangium-bearing tips, showing the short deflected tetrastichously arranged branchlets.  $\times 22$
- FIG. 2. *Griffithsia chilensis*. Branch bearing three laterally placed sporangial clusters, showing incurved branchlet tips and numerous polysporangia.  $\times 33$



## EXPLANATION OF PLATE II

FIG. 1. *Bryopsis peruviana*. A group of plants, showing the form of the pinnate blades.  $\times 1.5$

FIG. 2. *Polysiphonia paniculata*, showing the habit of growth.  $\times 1.0$



### EXPLANATION OF PLATE III

*Halopteris hordacea*. The habit of a fertile plant, showing the massive base and branching. Most of the tertiary branch tips may be seen to be fertile.  $\times 1.1$





## EXPLANATION OF PLATE IV

### *Eisenia Cokeri*, two juvenile stages

- FIG. 1. Initiation of the smallest lateral lobes near the basal meristematic area. The irregularity of the end of the primary blade is due to tearing rather than to extensive decay.  $\times 0.5$ . Howe's figures (1914, pls. 14-16) show the mature stages adequately.
- FIG. 2. Older stage with lateral lobes approaching the length of the primary blade, which has begun to decay.  $\times 0.3$

PLATE IV

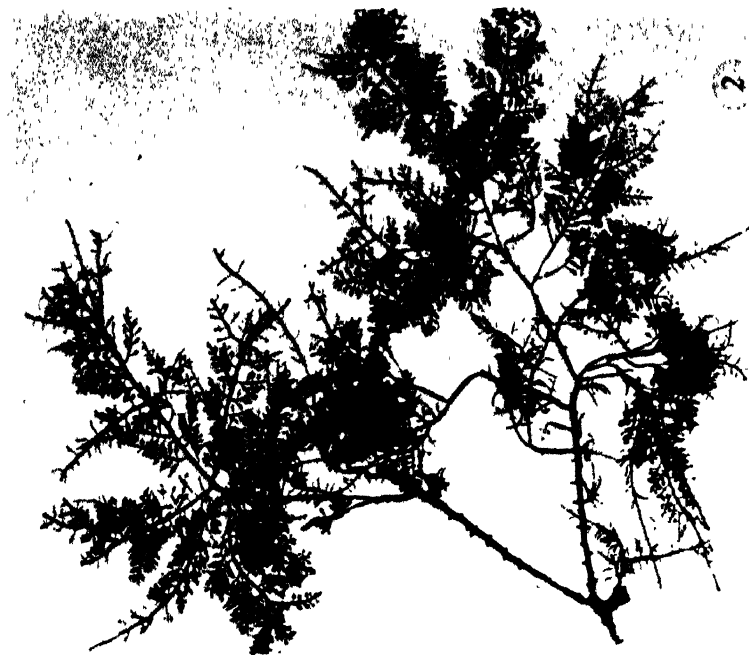
TAYLOR



## EXPLANATION OF PLATE V

FIG. 1. *Laurencia paitensis*. A considerable portion of a plant, the base concealed by *Ulva*, but showing the open branching.  $\times 0.8$

FIG. 2. *Gelidium filicinum*. The major portion of a plant, showing the branching.  $\times 1.0$



## EXPLANATION OF PLATE VI

### *Gelidium congestum*

FIG. 1. A portion of a relatively loosely branched plant, showing the basal attachments, naked erect axes, and the crowded upper branching.  $\times 2.1$

FIG. 2. A clump of a more densely branched specimen, showing the entangled basal stems and several erect axes with very crowded upper branching.  $\times 2.1$



## EXPLANATION OF PLATE VII

### *Corallina chilensis*

FIG. 1. A specimen from Areschoug's Peruvian Phyc. Extra-Europ. Exsic. 68.  
× 2.0

FIG. 2. A specimen from Callao, collected by Schmitt. × 2.0

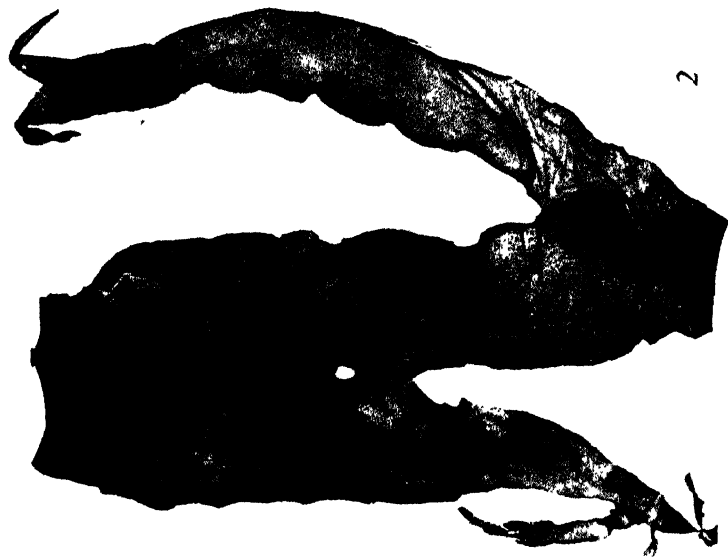
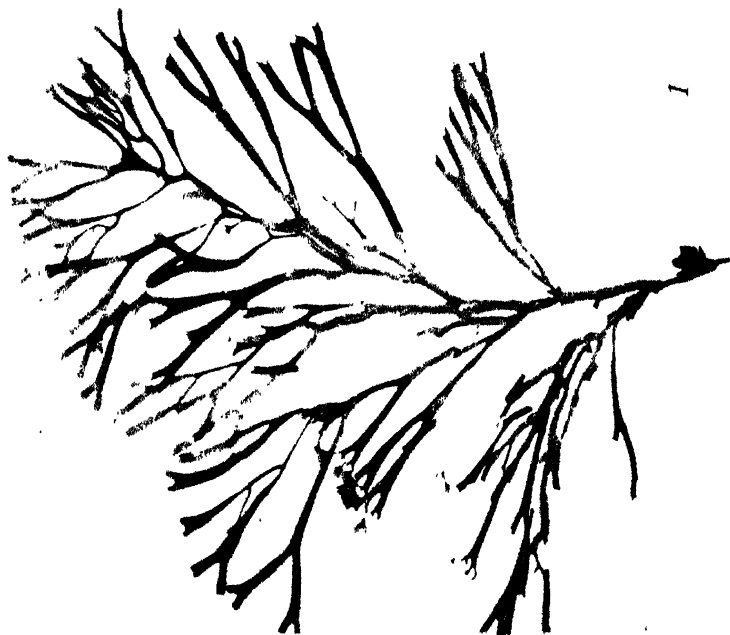




## EXPLANATION OF PLATE VIII

FIG. 1. *Dendrymenia Corallina*. An erect axis with a few indeterminate branches and small upper dichotomous blades. The acute-forked tips of some blades are due to the disintegration of terminal sporangial sori, which has left the margins as paired projections.  $\times 0.5$

FIG. 2. *Halymenia foliacea*. A complete cystocarpic plant, showing the small base with proliferations and marginal lobes, and forking tip.  $\times 0.3$



## EXPLANATION OF PLATE IX

- FIG. 1. *Iridophycus ciliatus*. Major portion of a tetrasporangial blade, showing the small base and the minutely ciliate lower margins.  $\times 0.75$
- FIG. 2. *Grateloupia denticulata*. Portions of a plant, showing the shape of the branches and the spinulose projections from them.  $\times 0.37$



## EXPLANATION OF PLATE X

FIG. 1. *Sebdenia chichensis*. Two plants showing alternately expanded and narrowed blades with acute base and rounded tips.  $\times 0.45$

FIG. 2. *Sebdenia afuerensis*. A plant showing the very irregular branching.  
 $\times 0.55$



## EXPLANATION OF PLATE XI

### *Gigartina paitensis*

FIG. 1. A very loosely branched example.  $\times 0.9$

FIG. 2. A very closely branched example.  $\times 1.2$ . Intermediates between these were represented in the same collection

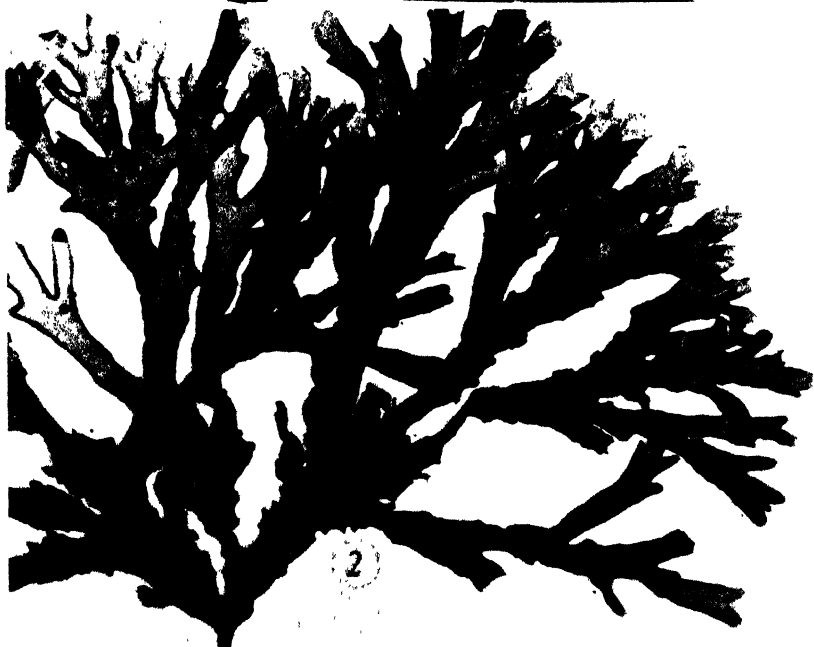




## EXPLANATION OF PLATE XII

### *Cryptopleura cryptoneuron*

- FIG. 1. A small portion of a spermatangial plant, showing the veinlets and the relatively broad segments strongly lobulate-cripsed below. The paler marginal spermatangial sori show faintly near the left-hand and the lower right-hand margins of the figure.  $\times 1.0$
- FIG. 2. The major part of a tetrasporangial plant, showing the relatively narrow segments somewhat criped in the lower portions. The marginal tetrasporangial sori are quite dark and are evident on most of the upper branches.  $\times 0.65$



## EXPLANATION OF PLATE XIII

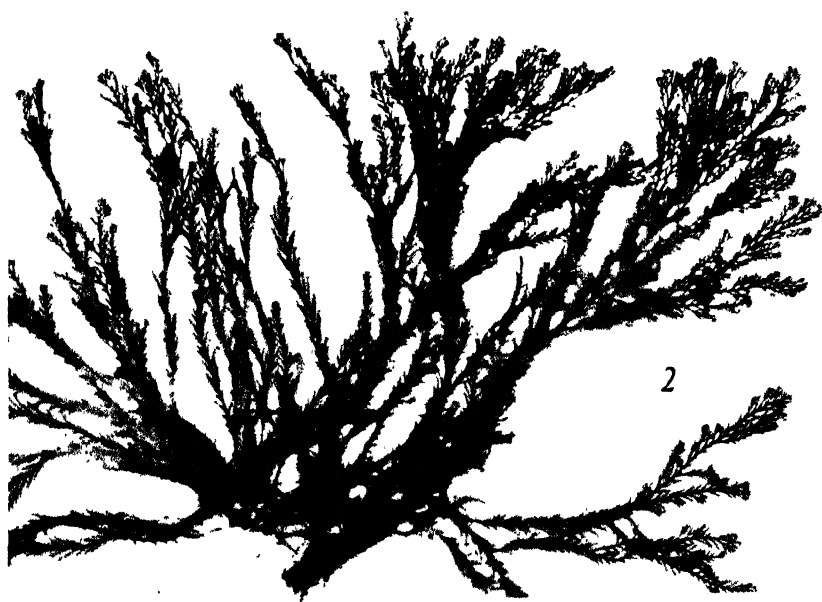
- FIG. 1. *Hemineura Hassleri*. The major portion of a sporangial plant, showing the branching of the axis and the lobing and marginal branching of the blades, which have strong midribs. The small, dark fertile lateral lobules can be distinguished.  $\times 0.4$
- FIG. 2. *Cryptopleura peruviana*. A portion of a large and old plant, turned on its side. The axis runs from the left-hand border down toward the right and bears numerous proliferous branches.  $\times 0.5$



## EXPLANATION OF PLATE XIV

FIG. 1. *Streblocladia camptoclada*. The upper branching of a clump, showing the habit.  $\times 2.2$

FIG. 2. *Pterosiphonia pennata*. The major portion of a clump, showing the habit, the main axes subsimple below, alternately branched above, with alternate simple branchlets throughout.  $\times 1.7$





# FORESTRY





## OCCURRENCE OF FUNGI IN THE MAJOR FOREST TYPES OF ALASKA \*

DOW V. BAXTER

THE study of fungus populations in the various stages of development of a forest is relatively new, although it has been known for a long time that they play a definite rôle in the life cycles of plant communities. Often fungi are directly responsible for the changes in the composition of associations of higher plants. Furthermore, they frequently affect the rate of change. It seems clear, therefore, that ecological-pathological studies of the "normal" fungus cycle in major forest types will aid in planning effective measures for minimizing losses caused by pathogenic fungi. If it is possible to follow the history of a forest environment, with its types of fungus populations, back through various periods of development, we can likewise predict the probable future of certain plant associations, together with their forest fungi. In other words, it should be possible to foretell with a reasonable degree of accuracy what "pests" will occur in our future stands and, perhaps, what they will do. Of course, it is not feasible to forecast unusual outbreaks caused by fungi brought in from other countries or from outside areas any more than it is for an insurance company to make predictions for the appearance of an "unusual" disease in the human race. With information available concerning the incidence of certain fungi in different classes and age groups of stands, however, the forester will be able to anticipate need for protection and in some cases, at least, to take measures to prevent pests from developing (1).

\* Throughout the several field seasons' work in Alaska much credit is to be given to the men, largely from the School of Forestry and Conservation of the University of Michigan, who aided in the collection of the specimens in the field, sometimes under difficult circumstances. Frank H. Wadsworth, W. Morris Morgan, Gordon L. Watts, Charles G. Allen, Robert Dimler, George Dick, Fred R. Walker, and Joe Hessel assisted in making the transects reported in this series of papers. My thanks are also due to the Horace H. Rackham School of Graduate Studies and to H. H. Bartlett, E. B. Mains, and Miss Ruth Chen-Ying Chou, all of the University of Michigan. Professor H. S. Jackson identified the several species of Alaskan Thelephoraceae mentioned.

My own studies of the rôle of fungi in plant succession have been carried out largely in Alaska, and in this article I present a series of observations made in five different forests of the Territory.

#### I. FOREST AND FUNGUS SUCCESSION OF INTERIOR RIVER VALLEYS WITH MEANDERING STREAMS

(Figures 1-2; Plates I-II)

The area that I have chosen as exemplifying the interaction of tree and fungus populations is in the Yukon River system below the mouth of the Tanana River, southwest to the mouth of the Koyukuk. The rivers of this large region have been cutting downward in some places, while depositing silt and gravel in others, until at present all the larger watercourses have broad, mature valleys. Cutting and deposition are still under way as the streams in flood sweep across the meanders, with consequent changes in the physiography of the region (2).

The forests of the alluvial flats are the largest and commercially the most important in the area. They contain chiefly white spruce (*Picea glauca* Voss.), balsam poplar (*Populus tacamahaca* Mill.), willows (*Salix* sp.), the white birch (*Betula alaskana* Sarg.), and alder (*Alnus crispa* Pursh). Willows are found on the new stream deposits and therefore commonly line the banks where deposition is in progress. The white and the black birches are small, especially the latter. Alder, often occurring with spruce, is not seen from the rivers except where the stream is cutting into a bank.

#### *The Transect Method for Study of Succession*

Forest succession and the occurrence of fungi in the different types were studied in detail by means of transects. One of these was established a mile below the junction of the Yukon and Koyukuk rivers (line A-B, Fig. 1). This transect crosses three bars designated A, B, and C (Fig. 2).

The first vegetation to appear on a new bar consists of willow, a few sedges, and some weedy annuals. Between the river and a sharply defined strip of driftwood there is no vegetation. Apparently the Yukon stood at the level of the driftwood until willows of the near-by region had borne fruit, and so had prevented the seed from falling on the area between the driftwood and the shoreline.

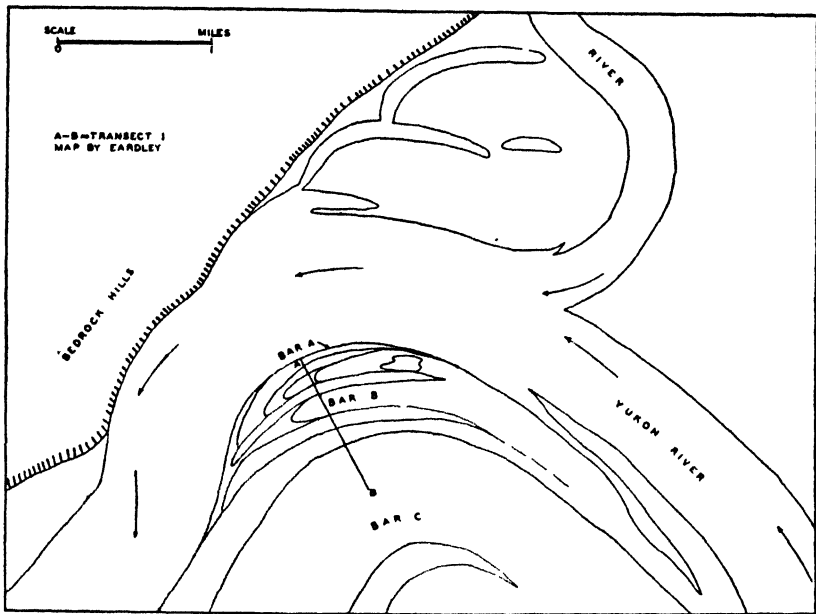


FIG. 1. Bar formation at the mouth of the Koyukuk River. Transect line A-B extends through the young forest in Bar A to the climax forest in Bar B

At a slightly higher level than that of the driftwood willow seedlings grow abundantly. Other tree species found on older bars do not occur on this site. Balsam poplar was not found but may be expected in such areas to a limited extent since it is common elsewhere along the Yukon.

The willow seedlings are so severely infected with rust, *Melampsora Bigelowii* Thüm., that many of them have been killed. The leaves of the living plants are red with the spores. In spite of the fact that numerous willows have been eliminated by the rust, the density of the stand has been maintained by the increase in size of the trees. A number killed by the fungus would have died regardless of infection because of severe competition for light.

The young willow forest reaches an age of approximately thirteen years on the older part of Bar A, where the trees are three to four inches in diameter. Competition for light is severe, and the number of stems has been reduced to 2,800 per acre.

The leaf rust of willow appears in this forest, but its effect upon

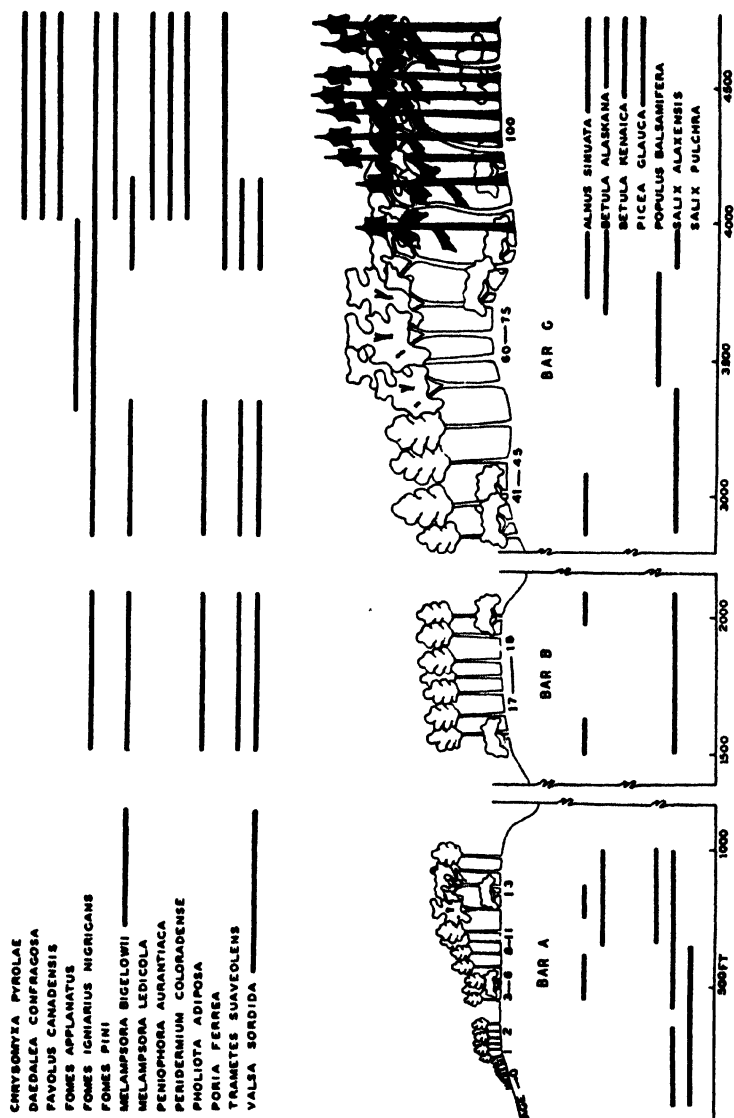


Fig. 2. Profile of a transect in the Lower Yukon Valley, Koyukuk, Alaska, as illustrated in Plates I and II. Lines drawn beneath the trees represent the species present. The lines above the trees represent the significant species of fungi that appear in the various forest communities. The distances of Bars A, B, and C from the Yukon are indicated in feet.

these older trees is not noticeably significant. *Valsa* cankers, however, become prevalent.<sup>1</sup>

The overmature willow forest, forty to forty-five years old, is found on Bars *B* and *C*. Disease in the species here is more prevalent than on Bar *A*. On the willows *Valsa* cankers are often accompanied by rot caused by *Favolus canadensis* Klotzsch. Two other heart-rotting fungi are *Pholiota adiposa* Fr. and *Trametes suaveolens* (L.) Fr. Young cankers often start around the bases of branch stubs and increase to a length of two feet or more. It is not unusual to see stems four and one-half inches in diameter with cankers six inches wide. The rust fungus, which is present, however, causes little or no serious damage.

In general, balsam-poplar forest follows the willow, although *Salix* and *Alnus* persist. Many willows in this forest are decayed by *Fomes igniarius* (L.) Gill. var. *nigricans* Fr. This heart-rotting fungus appears to be significantly destructive for the first time at this stage in the development of the forest and, together with *Pholiota adiposa*, causes a large amount of rot.

The mature forest is marked by the presence of spruce (*Picea glauca*). The willow has largely disappeared during the natural rotation, so that only a few live relicts remain. Birch (*Betula alaskana* Sarg.) is common in this forest and, in some low areas, alder (*Alnus crispa* Pursh) may occur.

The spruce, which is the least decayed of all trees on the transect, was generally sound. The comparatively little rot observed in standing spruce here is caused by *Fomes Pini* (Thore) Karst.

Though seriously attacked by *Fomes igniarius nigricans*, the birch will probably remain in the type to some extent, since it normally maintains itself as a minor constituent of mature spruce forest.

#### *Résumé of the Tree and Fungus Development in the Forest of the Lower Yukon River*

The young forest on new alluvial deposits of the lower Yukon is subject to a series of attacks by various fungi which affect the survival of successive forest trees. *Melampsora Bigelowii*, the first

<sup>1</sup> Young willows with diamond-shaped cankers are often cut and used for ornamental purposes. The bark is removed from the sticks, which are then highly polished and finished.

fungus to appear, is prevalent on the young willow of Bar A, where the seedlings, less than one year old, are killed by the rust, presumably selectively.

Other fungi and diseases do not appear until the crown canopy of the trees has closed over. On Bar B, for example, as many as six different fungi are common in the stand, including species that cause rot and cankers. In the willow forest forty to forty-five years old nearly half of the trees were damaged by either the canker-causing fungus, *Valsa sordida* Nitsch., or by heart-rotting fungi, and many by both. The chief heart-rotting fungi here are *Pholiota adiposa*, *Favolus canadensis*, and *Fomes igniarius nigricans*. The first is generally the most common, though in some areas either of the other fungi may be found more often.

The forest of this meander belt is also subjected to adverse conditions of site, such as frozen subsoil and ice damage. When the willow pioneers have closed over, changes in fungus populations will result, which may finally open up the stand. Growth of alder, birch, and spruce is thus facilitated. These different host species add directly to the fungus flora of the stand. The balsam-poplar forest, on the other hand, does not support a rich fungus flora. In the climax forest a number of fungi which were significant earlier in the history of the forest have disappeared. *Trametes suaveolens* and *Favolus canadensis* are examples.

The incidence of certain additional rust fungi has been favored by the recent appearance of their alternate hosts in the forest. *Pyrola*, *Ledum*, *Vaccinium*, and *Chamaedaphne* are examples of such hosts. The rusts which infect them are broom-stimulating on the spruce and, therefore, deform the tree, or the mycelium is not perennial in the twigs but is confined to the infected needles.

Fungi which destroy the heartwood of the spruce cause more damage than the rusts in the Alaskan forest. The ring-scale fungus *Fomes pini* appears for the first time in the climax forest, but in the particular forest studied does not occur abundantly. Both white and black birch are badly diseased in the climax type by *Fomes igniarius nigricans*, the heart-rotting fungus, which is the pathogen. Among the other fungi most common in this type, but not on the green standing timber, are *Trametes serialis* Fr., *T. variiformis* Pk., *Fomes pinicola* Sw. ex Cooke, *Poria xantha crassa* Karst., and *Poria crustulina* Bres. Members of this list are important in Alaska because they

destroy structural timbers. These plants are not found in the earlier communities mentioned.

## II. FOREST AND FUNGUS SUCCESSION AFTER THE RETREAT OF A MOUNTAIN GLACIER

(Figure 3; Plates III-V)

It seemed of especial interest to determine the succession of woody vegetation in relation to the fungus population after the retreat of a mountain glacier. The area selected for study was located in the spectacular glacial region about Deadman's Glacier and the Bartlett Glacier near Tunnel, Alaska. These glaciers are in the old "loop district" of the Alaskan Railroad that ran to Anchorage from Seward, not far from the summit of the Chugach Mountains.

After the recession of the ice here there is a continually expanding land area exposed to plant invasion. Successive developmental stages of the forest, from pioneer to climax, may be seen in order as one goes away from the front of the glacier.

Nearest to the present ice edge the gravel is bare of plant life. Willows are among the first woody plants to colonize it. The most conspicuous herbaceous plants of the gravel are *Epilobium latifolium* L. and *E. angustifolium* L., which persist until eliminated from Salix by shade. Still farther back from the ice willows, together with alders, increase in size and number, forming dense thickets. Finally, a forest of mountain hemlock, *Tsuga Mertensiana* (Bong.) Carr. appears.

In the various phases of succession in the forest here there are notable differences from those of either the interior forest or those directly on the Pacific coastal slopes. The mature poplar forest, a phase in the succession of the river-bottom types of interior Alaska, as well as one following ice retreat in the development of the forest along the Pacific coast, is not significant in the present area.

Spruce is prominent in the climax forest of both the interior and the coastal forest. White spruce (*Picea glauca* Voss.) may actually form pure stands in many areas of the interior. On the coast a valuable commercial species, Sitka spruce (*Picea sitchensis* (Bong.) Carr.), appears in the climax. In general, however, hemlock (chiefly *Tsuga heterophylla* (Raf.) Sarg., but in some areas *T. Mertensiana* (Bong.) Carr.) grows under the spruce. Finally, a climax forest is



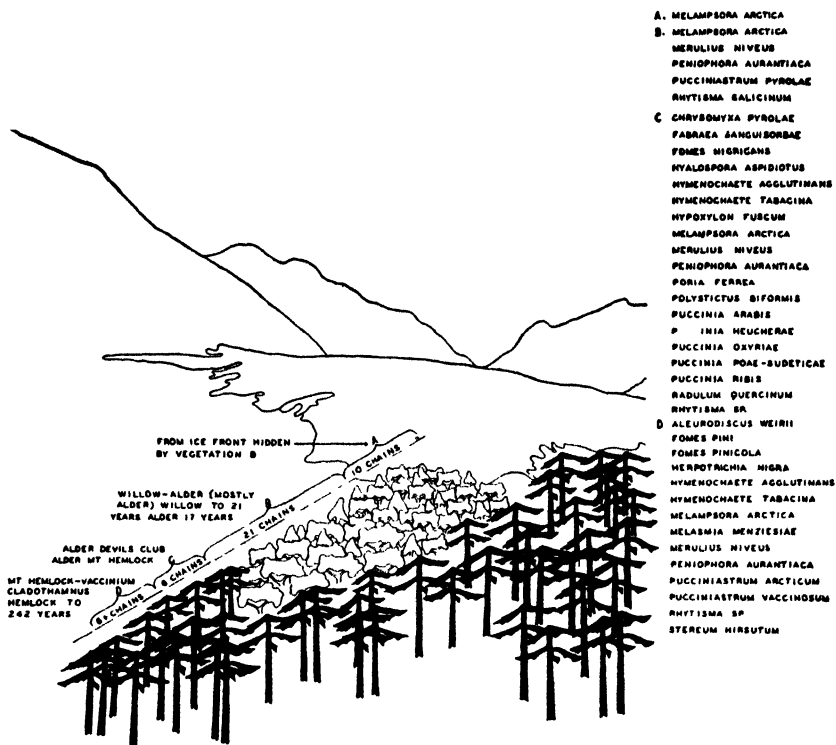


FIG. 3. Outline of vegetative types encountered from pioneer stages to the climax after ice retreat, as illustrated in Plates III and IV. Significant fungi that occur in the types are listed according to the zones that indicate various phases in the development of vegetation. Zone A (see Pl. III) is the area most recently freed from ice, but in the photograph it is hidden by the vegetation of Zone C

formed consisting of approximately three fourths hemlock and one fourth spruce. Spruce does not occur in the transect under discussion, but the succession proceeds directly from the willow and alder phases to the hemlock.

A transect one chain wide was run from the edge of the glacier, through the area of the first willows to invade the ice-freed ground, then through the willow and alder forest, and into the climax type, consisting largely of mountain hemlock. The fungi growing on the various trees and woods were recorded. The results were plotted and are presented in part in Figure 3.

Willows, which are among the first plants to colonize the ground

after ice retreat, are attacked during their first season by *Melampsora arctica* Rostr. At the glacier front, as in the interior meandering river belts, *Melampsora* affects the early development of the forest. Seedlings less than one year old are infected, and relative susceptibility to rust may be a material factor in natural thinning of the trees.

As soon as shade and competition become significant among the smaller broad-leaf trees (willow and alder) certain fungi are prevalent. *Hymenochaete agglutinans* Ellis on willow is one of them. *Stereum hirsutum* Willd. ex Fr., *Merulius niveus* Fr., and *Peniophora aurantiaca* Bres. are all common on alder. The complete decay of alder, however, is due to *Poria ferrea* Pers. ex Romell (see Fig. 3). Indeed, this fungus probably causes more decay of alder throughout Alaska than does *Fomes igniarius* (L.) Gill. var. *nigricans* Fr.

In the climax coniferous forest the same species of wood-rotting fungi that bring about decay of standing green trees and of fallen material in both interior and strictly coastal forests are present. *Fomes pini* (Thore) Karst. and *F. pinicola* (Swartz) Cooke are examples. *Aleurodiscus Weirii* Burt, reported from Idaho and British Columbia on *Abies grandis* Lindl., *Thuja plicata* Donn., and *Larix occidentalis* Nutt., is on hemlock in the climax forest.

The brown-felt fungus, *Herpotrichia nigra* Hart, occurs more commonly here in transects in the Chugach Mountains than in any of the others mapped. This is to be expected, since it is usual to find the organism at relatively high elevations or in localities of much snow. Large leaf areas become matted together by the mycelium, which grows over the foliage and induces death of the leaves and twigs of the host, chiefly by smothering.

Finally, it is of interest to note that certain prevalent fungi of the interior either are rare or do not appear in this forest type at all. The abundant rust fungus *Peridermium coloradense* A. & K. that causes witches'-brooms of white spruce in the interior forest does not occur in this area. Likewise, *Trametes isabellina* Fr., which commonly attacks fallen coniferous timbers throughout much of the Yukon Territory and interior Alaska, was not recorded on the transect.

It was observed that the farther away tree-infecting fungi are from the ice, the greater is their number up to a point where all the species of the Tsuga forest are present. Fungus populations, how-

ever, often depend not so much upon the number of different tree species but, in the case of the rusts, upon the abundance of specific and sometimes alternate hosts. For the most part the wood-attacking fungi occur where there is greatest abundance of host species within the forest. Here in the glacier-front forest the largest population appears to be in the "subclimax" type and just before the forest becomes mostly overmature hemlock, being determined by the factors of abundance and age of the tree species.

For many fungi found on the transect the age of the timber is a salient factor. *Fomes pini*, for example, was noted only in the mature stands of hemlock. The size of the wood may be significant with reference to the occurrence of such fungi as *Fomes pinicola*. It appears only on the large pieces of slash and stumps.

Many of the scavenger<sup>2</sup> fungi that are among the most ubiquitous in the states are not numerous here. *Polystictus versicolor* (L.) Fr. on hardwood slash and *Lenzites saepiaria* Fr. on coniferous slash are examples of species familiar farther south which are rare in this part of Alaska. *Pol. versicolor* is usually found, however, on woods other than those that occur in the Territory, and the glacial-front site under consideration is too wet for the best growth of both these species.

### III. FOREST AND FUNGUS SUCCESSION WHERE FLORA INCLUDES SPECIES CHARACTERISTIC OF BOTH THE COASTAL AND THE INTERIOR FORESTS

(Figures 4-5; Plates VI-VIII)

A part of the Kenai Peninsula near the Russian River was selected for a transect study because the forest consists of species ordinarily confined to the coastal region and those of the Alaskan interior continental area. The geographical relations are indicated in the sketch map (Fig. 4). The country selected for observation illustrates more strikingly than any other I have discovered in North America the intermingling of interior continental spruce (*Picea glauca* Voss.) with the Sitka spruce of the rainy coastal forest (*P. sitchensis* (Bong.) Carr.). The extraordinary physiography of the region favors this mixing of types. High ranges along the Alaska

<sup>2</sup> It is common to refer to species such as *Polystictus versicolor*, which destroy fallen and dead timber, as "scavenger" fungi.

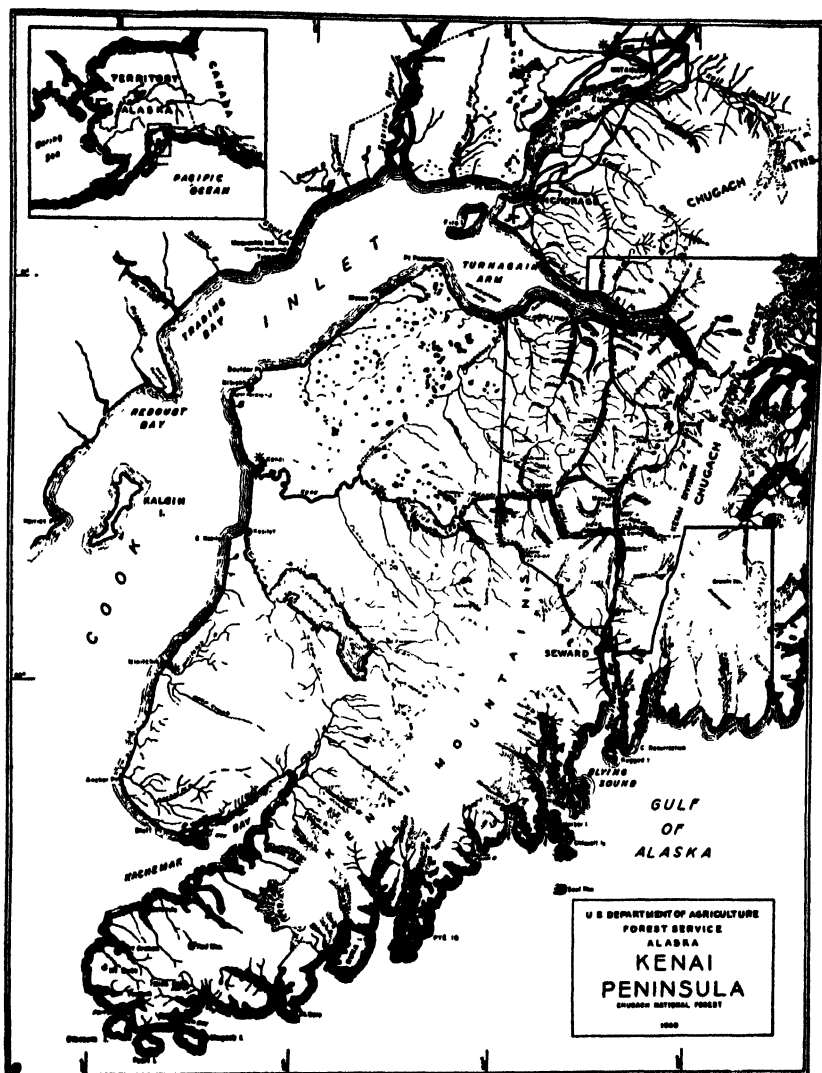


FIG. 4. The Kenai Peninsula, near the Russian River, was selected for a transect study because the forest consists of species ordinarily confined to the coastal region and of those of the interior continental area. The incidence of forest species is influenced by Cooke Inlet, which is a long fiordlike estuary typical of much of the sinuous coast line of Alaska, but reaching through the heart of the coast ranges to country with a central plateau climate near Anchorage

coast from the cape on the east side of Cooke Inlet to the northeast and east along the coast behind Seward and Prince William Sound produce a rain shadow over the central plateau, which has less annual rainfall.

Cooke Inlet is a long fiordlike estuary typical of much of the sinuous coast of Alaska, but reaching through the heart of the coast ranges to country with a central plateau climate near Anchorage (Fig. 4).

Forest succession and fungus populations in the various forest types were studied by a number of transects which formed a line through the white-spruce forests of the Alaskan interior types to the Sitka spruce-western hemlock forests at the base of a mountain (this came to be known by residents as "Baxter Mountain" on account of our party's activity there). Another transect was run up this mountain through the forest of Sitka spruce and western hemlock and through the mountain hemlock (*Tsuga Mertensiana* (Bong.) Carr.) to the alpine tundra (Fig. 5).

The interior forest consisted largely of aspen (*Populus tremuloides* Michx.) and white spruce (*Picea glauca*). The aspen, which appears after fires, is a common agent of destruction in the Alaskan interior forests, but is rare in the rain forest of the coast. Some birch (*Betula alaskana* Sarg.) also occurs. White spruce soon invades the aspen areas and eventually eliminates the "temporary forest" of *Populus tremuloides*.

The aspen is badly damaged by moose browsing. The effect, however, amounts to a "release" of the spruce and so may be considered beneficial with reference to commercial forest production, since spruce is the more valuable tree. *Fomes igniarius* (L.) Gill. attacks the aspen and causes its decay.

Birch leaves are often red with the spores of the birch-larch fungus, *Melampsoridium betulinum* (Pers.) Kleb. There is no larch, however, in the area.

The spruce soon becomes infected with the witches'-broom fungus, *Peridermium coloradense* A. & K. This rust is exceedingly common in the new-growth interior forests and often (though not necessarily) after fires. *Trametes variiformis* Peck and *T. odorata* (Wulf.) Fr. are among the chief fungi that decay old fallen spruce timbers remaining from the original spruce forest that preceded fire and the new poplar-spruce succession.

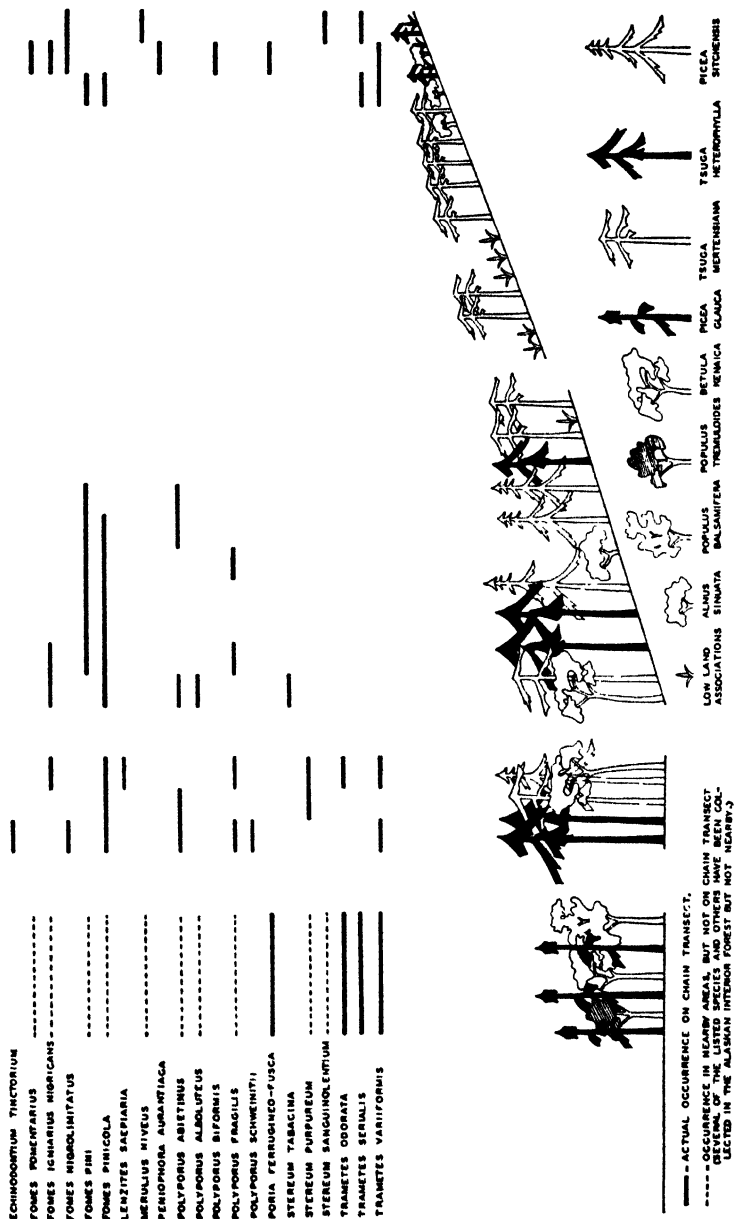


FIG. 5. Profile of a transect near the Russian River, Kenai Peninsula, as illustrated in Plates VI and VII. The interior forest is represented by the transect on the left. The transect passes through the coastal forest and up through the changing vegetative types as one climbs Baxter Mountain. Lines above the trees represent the chief wood-inhabiting fungi.

The mature coastal forest consisting largely of Sitka spruce and western hemlock is attacked by specific rust fungi; the Sitka spruce needles, for example, are infected with *Chrysomyxa ledicola* (Peck) Lagerh. This rust causes some defoliation of the trees, but the injury is not serious. Both Sitka spruce and western hemlock become damaged by heartrot caused by *Fomes pini*. *Echinodontium tinctorium* Ell. & Everh. occurs on the hemlock, and in some areas it is particularly destructive of the mountain hemlock. *Fomes nigrolimitatus* (Romell) Egeland is also present on stumps and fallen trees, and *Polyporus alboluteus* Ell. & Everh. is common on Sitka spruce logs.

Succession of trees and, therefore, of tree-rust populations of the Alaska coastal mountains differs from that of the interior river valley districts. Major differences appear in climax types where Sitka spruce, western hemlock, and, in some localities, mountain hemlock occur instead of white spruce or black spruce. Here, where the coastal and the interior forest types appear in the same region, just as they do in the typical nontransitional forests of the coastal and the interior areas, well-defined relations exist between the different stages in the development of the forest and the species of fungi present.

The witches'-broom fungus, *Peridermium coloradense*, on white spruce, does not here attack Sitka spruce under natural conditions. Rusts are, of course, known for their high degree of specificity, but this is the first field evidence which has come to light regarding the susceptibility of Sitka spruce and white spruce to this rust.

*Melampsoridium betulinum*, the birch-larch fungus, is abundant in the interior forest, but it does not appear in that part of the transect that represents the coastal forest.

The Indian-paint fungus, which causes much cull in western hemlock and most of the decay in the true western firs, appears on the mature hemlock, but it does not attack any of the coniferous species in the near-by interior forest. This unusual area is a notable example of one where the spores of a western wood-rotting fungus (*Echinodontium tinctorium*) are undoubtedly present in the same forest with one of the northeastern conifers (*Picea glauca*), yet the fungus has not been found on this spruce. Eastern hemlock does not occur in the forest.

Both eastern as well as western hardwood-rot fungi in standing timber are seen on the species of the interior and coastal forest.

*Fomes igniarius* (L.) Gill. var. *nigricans* Fr. and *F. fomentarius* (L.) Kickx. are examples. These, in contrast to the restricted fungus just mentioned, may be found on woods of eastern or western distribution.

*Fomes nigrolimitatus*, first described from Lapland, is more frequent in the Alaskan coastal forest than in northern Europe. Here it occurs commonly on spruce in the mature coastal forest type, but it is not known on spruce in the interior forest.

Many of the fungi that destroy coniferous structural timbers in the northern United States are common to both the interior and the coastal forest. *Trametes variiformis* and *T. odorata* are in this group.

*Trametes variiformis* and other fungi of the same habit, largely confined to fallen timber, are more destructive of slash in the interior than in the coastal forest. Such common hardwood-attacking fungi as *Polyporus gilvus* (Schw.) Fr. and *Polystictus versicolor* (L.) Fr. (almost ubiquitous in the Lake States) are generally absent from both forest types in Alaska. *Polyporus radiatus* (Sow.) Fr., which might be expected on alder, does occur abundantly here.

One of the ecologically important facts which soon becomes too familiar to attract attention or to seem worth mentioning is that the rather rapidly growing slash-destroying fungus, *Fomes pinicola* (Swartz) Cooke, is conspicuously common in the coastal forest. The destruction of fallen timber, however, is slow beyond belief, for the reason that the precipitation is so great and evaporation so retarded that wood soon becomes covered with moss and, seemingly, is permanently water-logged; under these conditions the moss-covered wood remains undestroyed for a very long time and eventually even a sphagnum swamp, known as "muskeg," may be formed. It is often possible to observe such a muskeg on the side of a mountain where the forest has deteriorated into a swamp; in such places the change is accompanied by a relative decrease in wood-rotting fungi and a corresponding increase in mosses.

*Polyporus alboluteus* on spruce in the Kenai Peninsula extends through mixed interior and coastal forests, as it does in the majority of the states where any spruce grows.

The damaging root-rot fungus of conifers, *Polyporus Schweinitzii* Fr., although found commonly in the forests of the northwest Pacific, has not been observed in the white spruce timberlands of interior Alaska.



## IV. FOREST AND FUNGUS SUCCESSION ON KODIAK ISLAND

(Figure 6; Plates IX-XIV)

Kodiak Island is located where the forest is invading land not recently occupied by ice, but altered by volcanic ash. The limit of the coastal coniferous forest of North America is on the eastern part of Kodiak Island. Beyond it the vegetation is chiefly grassland and tundra. Reports on the higher plants of this area have been published by the National Geographic Society, but nothing is said about the fungi.

In June, 1912, this island was disastrously affected by the eruption of Mount Katmai, which was one of the most tremendous volcanic explosions ever recorded. Griggs (4) reports that an area as large as the State of Connecticut was covered with ash and pumice to a depth varying from ten inches to over ten feet. Small amounts of ash fell as far as nine hundred miles away. Kodiak, almost one hundred miles distant, was the largest settlement in the section. The blanket of ash, according to Mr. W. J. Erskine, of Kodiak, who took the party of the National Geographic Society to the mainland, transformed the Kodiak region into a whitish desert.

Kodiak Island is now again covered with a rich vegetation, but some observations made by Griggs (4) are of particular interest because many of the host plants for the rust fungi are involved in the changes that have occurred.

It must not be supposed that the old order of things has completely returned. The new vegetation is not altogether the same as that which was destroyed. It is true that the species are not the same as those dominant before the eruption, but the smaller species which formerly grew with the dominant plants were unable to pierce the ash blanket and were smothered. This was particularly true in the bogs or tundras, which formerly covered considerable areas. Even four or five inches of the ash was fatal to the bog plants, whose extermination was so nearly complete that it is difficult to find even individual survivors.

Thus while the salmonberries and high-bush blueberries are finer than ever, the low-bush blueberries and cranberries are entirely lacking.

Formerly many of the species that grew in the bogs were found in the alpine heath that used to cover the exposed mountaintops, but Griggs notes that the eruption was equally fatal to them. Since the visits of the National Geographic Society's parties to Kodiak further growth of plants has taken place, and undoubtedly there is now a richer vegetation, which in turn affects fungus populations.

Since these edaphic changes are unparalleled and since the coastal coniferous forest of North America ends so abruptly that photographs can be taken to show the virtual margin of tree invasion, an unusual opportunity was afforded to study fungus populations here under the conditions that have determined the forest and that permit its advance under the ameliorating influence of climatic change.

A transect one chain wide was established from the mountaintop back of Kodiak (Fig. 6). The beginning of the transect was beyond the edge of the advancing spruce forest and was run through that part of the eastern section of the island where the area is occupied by a dense forest of Sitka spruce.

The mountaintop vegetation is largely alpine in nature. Dwarf birch (*Betula glandulosa* Michx.) and *Empetrum nigrum* L. are among the common plants of this type. Dwarf birch was infected here by *Melampsoridium betulinum* (Pers.) Kleb., and *Empetrum nigrum* was attacked by the rust fungus *Chrysomyxa Empetri* (Pers.) Schroet. This fungus, which was abundant at least during the year that these studies were made, had previously been unknown from North America, but records of its occurrence in Asia are available. *Puccinia Heucherae* (Schw.) Diet. on *Heuchera glabra* Willd. was also collected. *Melampsora arctica* Rostr. occurs on the willows.

As one follows the transect from the alpine vegetation to the areas where Sitka spruce is invading previously unforested land for the first time, it is interesting, indeed, to the student of plant associations to note that there is nothing here comparable to the successional stages after fire in the interior forest, or after deposition of new alluvium in the river valleys. There is nothing to correspond, for instance, with the poplar stage of the successions. Rather, there is a nonforest climax formation meeting with a subclimax phase of the forest, and practically nothing occurs in the way of a transition. Climatic conditions are now favoring the extension of forest, which, in its climax phase (if it is to be like that of the coastal areas of the Chugach and Tongass National Forests bordering the Pacific), unrepresented on Kodiak, will be spruce-hemlock, but which in the subclimax phase, the only one yet represented, is spruce alone. Just at the forest edge goldenrod and fireweed (*Epilobium angustifolium* L.) are found. The rust *Coleosporium Solidaginis* (Schw.) Thüm., a less common fungus in Alaska than in the states, appears on the

CHAIN—	F	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
ASCOCALYX ABIETIS(?)																																		
FOMES PINI																																		
FOMES PINICOLA																																		
PERIOPHORA AURANTICA																																		
POLYPORUS RADIATA																																		
POLYPORUS SULPHUREUS																																		
POLYSTICTUS ABIETINUS																																		
PORIA FERREA																																		
STEREOUM PURPUREUM																																		

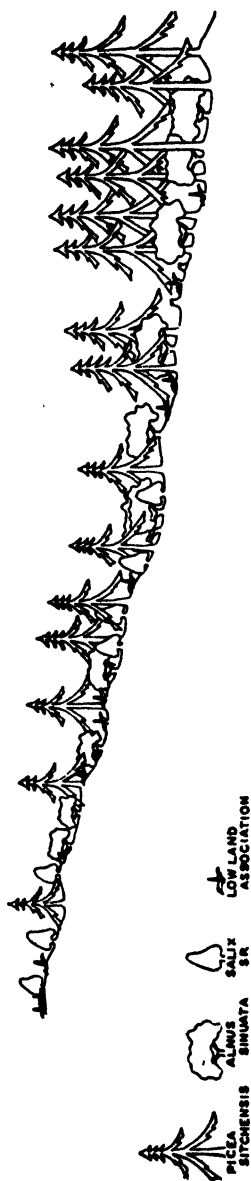


Fig. 6. Profile of a transect that extended from the top of the mountain back of the village of Kodiak to include a part of the Sitka spruce forest, as illustrated in Plates IX, XI, and XII. The occurrence of the chief wood-inhabiting fungi along the transect is illustrated by the bars above the trees

goldenrod, and the fireweed is infected with *Pucciniastrum Epilobii* Otth. Willows, which are also present, are infected with the rust *Melampsora arctica*. *Nectria Coryli* Fckl. also occurred on *Salix*. *Diaporthe sociabilis* var. *Sambuci* (E. & E.) Weh. was found on elder.

The spruce-needle rust, *Chrysomyxa ledicola* (Peck) Lagerh., is found almost as soon as the spruce is encountered. It causes much less damage on older trees.

Because the Sitka spruce trees are scattered when they first invade an area, they develop large and numerous limbs. It requires years for additional spruce that have seeded in later to grow up and eventually shade out the branches so as to cause their death. Much more time is necessary for these old limbs to fall off; but finally they offer points of infection for both *Polyporus sulphureus* (Bull.) Fr. and *Fomes pini* (Thore) Karst. In the oldest part of the forest many of the trees are defective because of heartrot caused by these two fungi. The coniferous structural-timber enemy, *Trametes serialis* Fr., was collected here on fallen spruce (3). *Pyrolas* appear commonly in the Sitka spruce forest, and many are infected with the rust (*Chrysomyxa Pyrolae* (DC.) Rostr.

Low areas within the Sitka spruce forest are occupied by alders, many of which are dying out. *Poria ferrea* Pors. ex Romell is the common cause of rot in the majority of the stems, but such fungi as *Polyporus radiatus* (Sow.) Fr. and *Pol. sterioides* Fr. ex Romell were also collected.

The forest on Kodiak does not contain either western hemlock or mountain hemlock. It will be recalled that *Tsuga*, in general, makes up almost 75 per cent of trees in the older Sitka spruce-hemlock forest elsewhere in Alaska in the coastal area bordering the Pacific Ocean. Fungi restricted to hemlock are therefore absent on Kodiak Island.

The rust fungus *Melampsoridium betulinum* on *Betula* was abundant in the alpine tundra on Kodiak Island, even though the host plant for the alternate phase (*Larix*) does not occur on it.

*Chrysomyxa Empetri*, known hitherto only from Asia, was found on *Empetrum nigrum*, which grows in the alpine tundra.

The salix rust *Melampsora arctica* was found throughout the transect, but is most abundant where the forest of spruce has not yet become densely stocked. Alternate phases of this rust appear on members of the Saxifragaceae.

*Coleosporium Solidaginis* is much less common throughout Alaska

than in most parts of the Lake States and in many other localities of the United States. However, this rust of goldenrod was found on the transect area mapped. Alternate phases of it are on species of pines, but there are no pines on Kodiak Island, nor are there any species of this genus over vast regions of the near-by mainland.

The rust that attacks *Epilobium angustifolium* L. appeared abundantly on the transect. It is of interest that on Kodiak Island not only are there no species of *Abies* that are hosts for the alternate phase of this rust, but that no representatives of this genus occur much nearer than the mountains that border the Yukon Territory.

*Puccinia Heucherae*, a common rust on the mainland, was found abundantly on Kodiak Island. It does not, however, have an alternate tree host.

The spruce-needle rust, *Chrysomyxa ledicola*, is present on *Picea sitchensis* (Bong.) Carr. The alternate phase of it occurs on *Ledum*, a bog plant that has probably survived the eruption of Katmai. It is to be noted, however, that the rust was found on the spruce host and not on *Ledum*. It is possible that association of both hosts may not be necessary for infection of the spruce.

Pyrolas, however, are low plants that would be easily buried by the ash. They are common on the island. Furthermore, the rust *Chrysomyxa Pyrolae* was recorded for the transect. It attacks Sitka spruce as well as species of *Pyrola*.

#### V. FOREST AND FUNGUS SUCCESSION AFTER THE RETREAT OF A GLACIER IN THE PACIFIC COASTAL REGION

(Figure 7; Plates XV-XVIII)

Forest succession and the occurrence of different fungus populations in the forest types that follow the ice retreat was traced near Valdez, Alaska, on Prince William Sound. Historically this area is well known because hundreds of prospectors crossed the Valdez Glacier on their way to the Yukon in the gold rush.

A 312-chain transect, one chain wide, was run from the foot of the glacier through the various types of vegetation that have developed since the retreat of the ice. The woody plants observed that were either substrata or hosts for the different fungi were recorded.

The first woody vegetation to appear after ice retreat consisted of willows and a few cottonwood seedlings. The willows were infected

with the rust fungus *Melampsora artica* Rostr. Farther away from the ice an old forest of cottonwood is found. Many of the trees are now dead, the result of alluvial depositions made by sudden rises of streams emanating from the glacier. Later colonizing plants have reinvaded these areas, and so the forest is actually in many stages of development. An unusually large population of wood-rotting fungi is therefore present as well as the group of rusts that are ordinarily found chiefly in the juvenile forest. The fungi noted here are indicated in Figure 7.

The climax forest of Sitka spruce and western hemlock prevalent in the coastal forests along the Pacific has not formed. It does occur, however, on near-by areas and supports, in general, the identical fungi found elsewhere for this forest type (2).

As in the first forest types of interior Alaska that appear on newly formed soil, the rust fungi are among the first to attack the invading willows after retreat of the tidewater glacier. *Melampsora arctica* is abundant, especially in the young forest. *Pucciniastrum Pyrolae* (Pers.) Schroet. does not appear until several years later, when favorable forest conditions have been created by the poplar, and therefore not until many years after the first willow and cottonwood have grown on the gravel bars. This rust appeared first in chain 213. *Pucciniastrum Epilobii* Otth. was found on chains 285, 286, and 287 (i.e. some distance from the ice). The tree host for this fungus is supposed to be *Abies*. Among the western species of this genus the fungus is reported on *A. concolor* Lindl. & Gord., *A. grandis* Lindl., *A. lasiocarpa* (Hook.) Nutt., and *A. nobilis* Lindl. There are no species of *Abies* at all in this part of Alaska. *Abies* is known to occur in the far-off panhandle region across the Gulf of Alaska. The fungus that causes tar spot of willow, *Rhytisma salicina* (Pers.) Fr., like the *Melampsora* rusts, also appears early in the life of the forest.

Most tree- and wood-inhabiting fungi, however, are not found until after the poplar has matured and until later vegetational associations appear. This phenomenon was observed in the development of the spruce forest in the meander belt of the lower Yukon and on many of the transects established elsewhere. On the Valdez Glacier transects, however, a relatively large number of fungi do occur in the poplar forest.

On the interior Alaskan transect, in contrast to the Valdez transect, plant succession from the willow to the poplar forest and

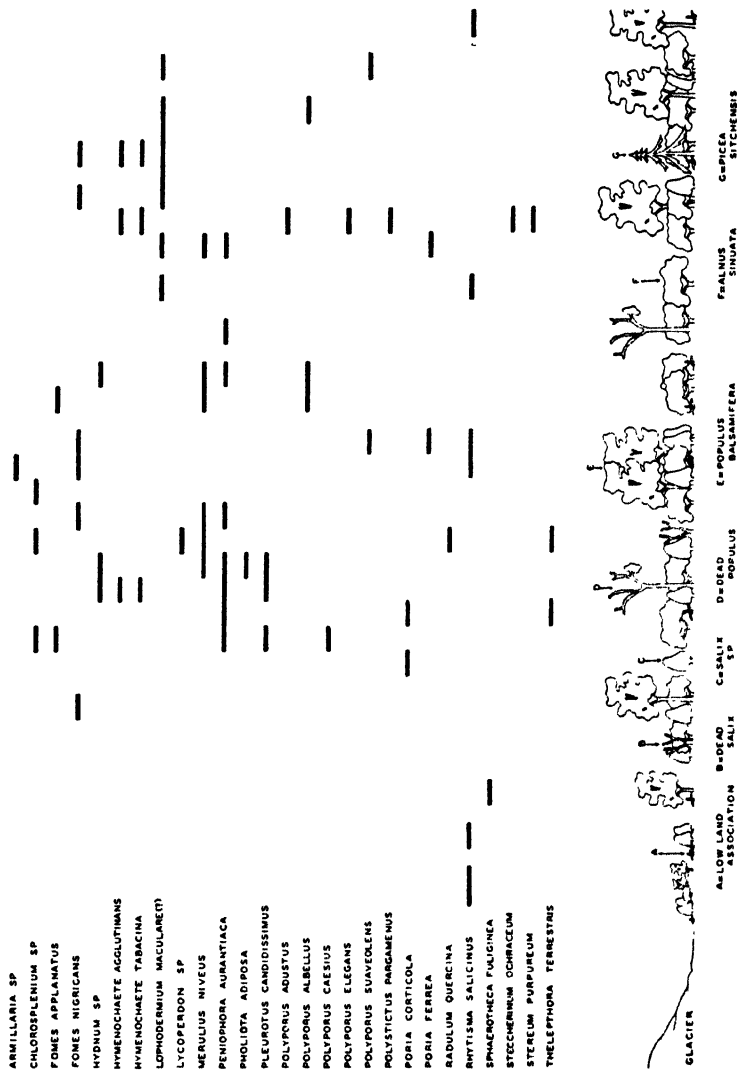


Fig. 7. Profile of a transect in the area of the Valdez Glacier, as illustrated in Plates XV, XVI, and XVII.  
Lines drawn above the trees represent the chief wood-inhabiting fungi present

to spruce has been gradual. In the Valdez area there is abundant evidence that the process has been interrupted and has not been a continuous one from pioneer phases to the climax forest. A large number of mature poplars that have been killed by sudden deposition of gravel from swollen glacial streams are present in the Valdez area. Partial burial by gravel has killed many mature cottonwood trees. This has resulted in reinvasion by colonizing plants and in unduly long persistence of vegetation that belonged to earlier phases in the succession. These plants are now associated with the dying and dead trees of a later phase. Consequently, fungi that ordinarily occur during different periods in the history of the forest are found here. Not only do catastrophes alter the species in the forest itself, therefore, but such environmental factors likewise have a marked effect upon the incidence of forest fungi.

UNIVERSITY OF MICHIGAN

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4. GRIGGS, ROBERT F. 1917. The Valley of Ten Thousand Smokes. National Geographic Magazine, 31: 13-68.



PLATES I-XVIII



FIG. 1. View as one looks west along the north edge of Bar A (see Fig. 1). The rows of seedlings along the water's edge came from willow seeds that were washed ashore during the spring. The beach on the river side was under water during the season when the seeds were disseminated

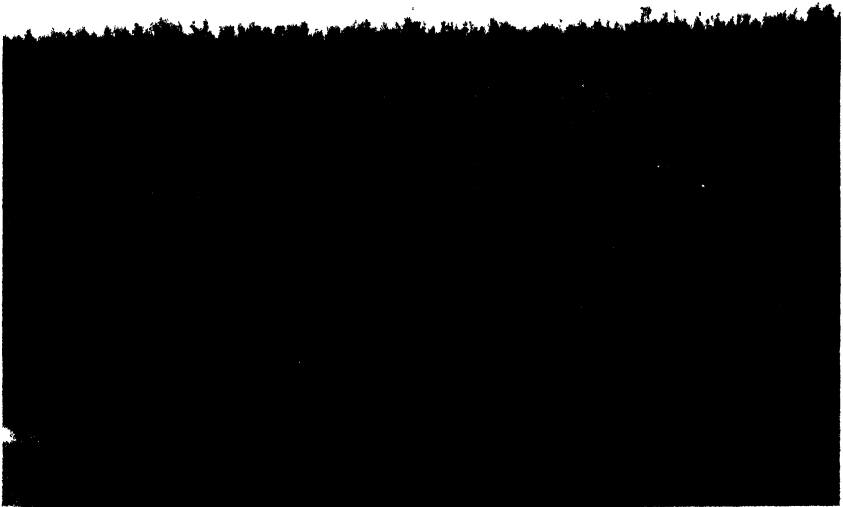


FIG. 2. The willow in the foreground is one year old; that in the background is two years old. This regular stairlike arrangement is characteristic of this vegetation





FIG. 1. Zone of vegetation that occupies the area between bars once under water. The ground cover consists largely of *Equisetum*, *Rubus*, and a few alders



FIG. 2. Interior Alaskan white spruce forest along a slough of the Yukon River





The area selected for the study of forest and fungus succession after the retreat of a mountain glacier in the spectacular region about the Bartlett Glacier, near Tunnel, Alaska. This glacier is in the old "loop district" of the Alaskan Railroad. The vegetation types, which are separated by the dashed lines, are indicated by letters. They correspond to those shown on the transect in Figure 3





FIG. 1. Alder thicket characteristic of Zone B and part of Zone C



FIG. 2. The mountain hemlock Zone D in the foreground. Looking toward the alder of Zone B and the ice front of the Bartlett Glacier







*Fomes pinus* (fruiting body in center) on *Tsuga Mertensiana* in mountain hemlock Zone D. This heart-rotting fungus is the representative of the genus here, although *Fomes pinicola* on fallen trees is common in this zone





FIG. 1

FIG. 1. Interior spruce, *Picea glauca*, Russian River transect, Kenai Peninsula

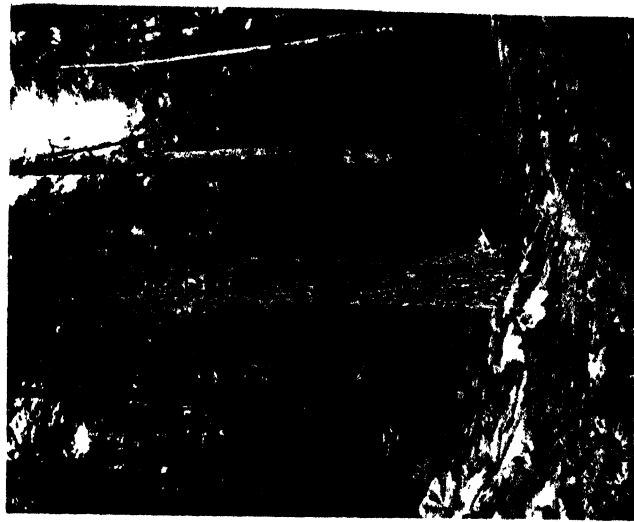


FIG. 2

FIG. 2. Alaskan coastal forest, consisting chiefly of western hemlock and Sitka spruce. The large-leaved plants in the foreground are devil's-clubs





FIG. 1. Lower Russian Lake (right foreground), looking toward Skilak Glacier, Kenai Peninsula. Fire-killed timber is common in interior Alaska. The transect included a part of Baxter Mountain (to the left)



FIG. 2. Hemlock forest on Baxter Mountain, through which the transect was run. A Sitka-western spruce hemlock forest grows at the base. White spruce of the Alaskan interior forest is to be seen in the central background and in the area of the Kenai (above center)



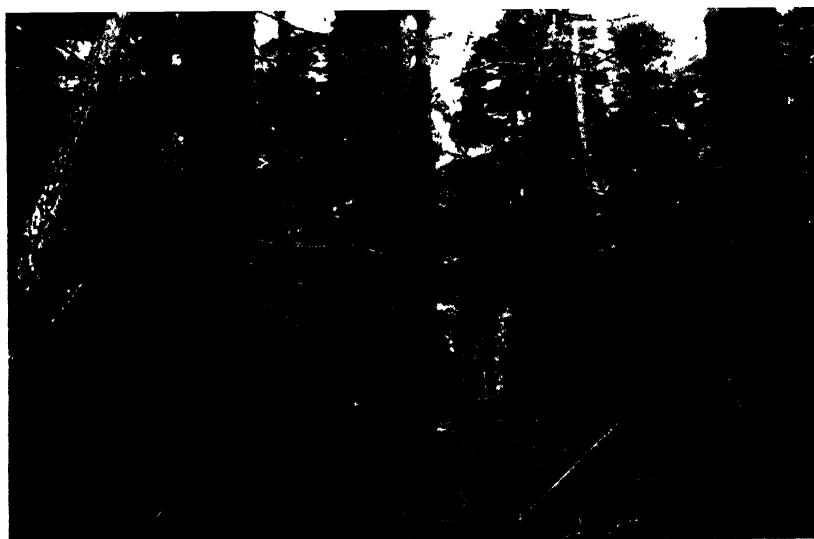


FIG. 1. Mountain hemlock type, Kenai Peninsula. This hemlock is over-mature and is badly decayed by *Echinodontium tinctorium*



FIG. 2. Mountain hemlock, on Baxter Mountain





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PLATE IX



The edge of the coastal coniferous forest in North America (at the extreme right in the photograph), with the town of Kodiak in the foreground. The photograph, taken in 1938, should be compared with the one published in the *National Geographic Magazine*, 31 (1917) : 15, which shows the grass vegetation on the mountain in August, 1916. The transect extends from the mountain in the background to the edge of the spruce forest





FIG. 1

FIGS. 1-2. The eruption of Mount Katmai in June, 1912, threw a mass of ash and pumice into the air which buried an area as large as the State of Connecticut. The ash, which fell like snow on the branches (Fig. 1), can still be shaken from the moss-covered limbs. A layer of ash (Fig. 2) buried the vegetation to a depth ranging from ten inches to over ten feet.



FIG. 2





FIG. 1. The beginning of the transect beyond the edge of the advancing spruce forest. The mountaintop vegetation is largely alpine



FIG. 2. Sitka spruce invading previously unforested land for the first time





FIG. 1. View from the mountain toward the village of Kodiak and Spruce Island. Early Russian maps show Spruce (Wood) Island, evidently so named because of the presence of timber during the period of their occupation.



FIG. 2. Sitka spruce forest invading grasslands of Kodiak Island. The transect extended into the forest







Sitka spruce and the remnant alder forest, Kodiak Island. *Poria ferrea* is common on alder here





FIG. 1



FIG. 2

FIGS. 1-2. *Polyporus sulphureus* (Fig. 1) and *Fomes pini* (Fig. 2), which are common causes of heart rot in Sitka spruce





Forests that have developed since the ice retreat, Valdez, Alaska. The transect studies were made in the forests in the middle foreground. The Valdez Glacier, not shown in the photograph, is to the left



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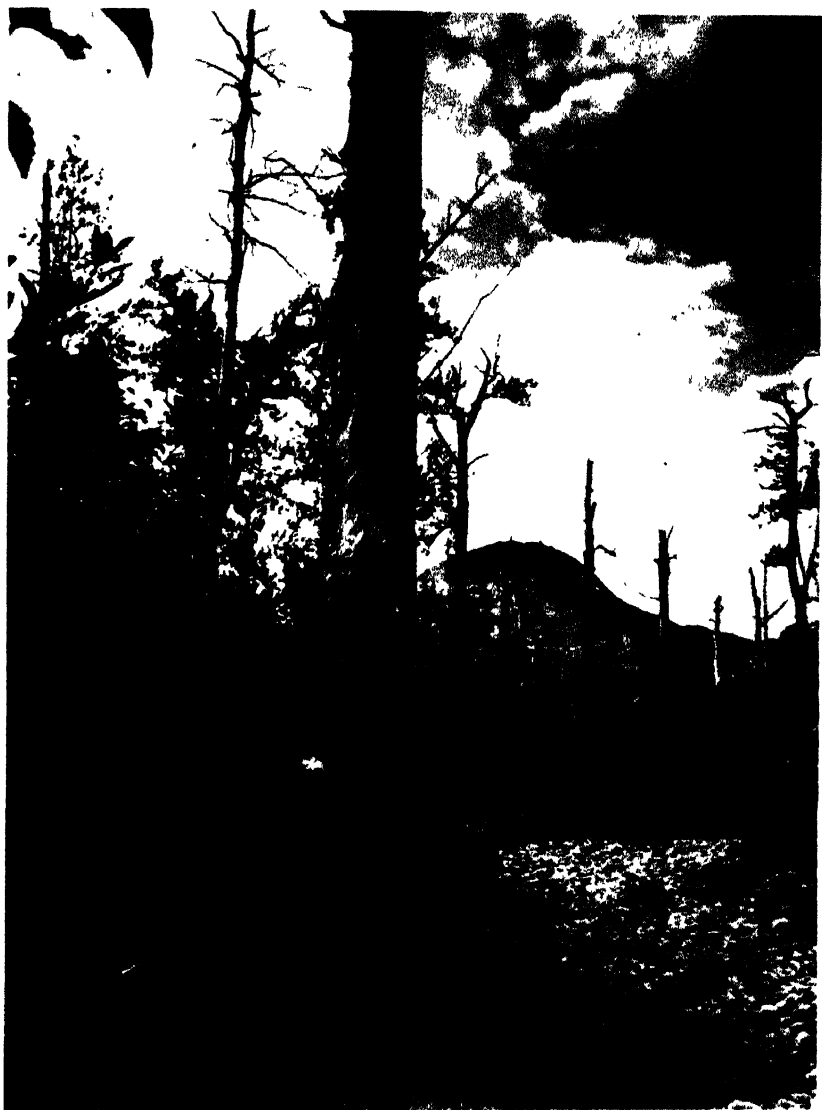
PLATE XVI



Edge of the Valdez Glacier. A 312-chain transect, one chain wide, was run from the foot of the glacier through the various types of vegetation that have developed since the ice retreat.







Mature poplars killed by the deposition of gravel from swollen glacial streams from the Valdez Glacier. This catastrophe has resulted in reinvasion by colonizing plants and unduly long persistence of vegetation that belonged to earlier phases in the succession





FIG. 1

FIG. 1. The use of the increment borer in determining tree ages on the Valdez transect



FIG. 2

FIG. 2. *Fomes applanatus* on dead *Populus lacamahaca*, Valdez transect



## SOME RESUPINATE POLYPORES FROM THE REGION OF THE GREAT LAKES. XVII \*

DOW V. BAXTER

THE merit of taxonomic effort is determined by its usefulness to others. In spite of the multiplicity of lists and descriptions of the polypores of this or that area no work which covers a continent is available. Furthermore, even for a region no treatise exists which seems to be generally usable.

There is much disagreement not only between American and European classifications, but among American reports themselves. Some represent strictly morphological viewpoints, whereas others have to do entirely with classifications based upon physiological reactions of the fungus. Still others attach considerable importance to the reactions of the host to a single species or race of a wood-rotting fungus and are definitely interested in the ecological relationships as well. Many whose activities are directed to prevention, control, and salvage measures point to the number of names often applied to the same fungus and, because of the many possible approaches to the subject, believe that it is now almost a hopeless task to identify positively some of the fungi with which they are concerned.

Furthermore, much difficulty is experienced in interpreting data of the fungi in culture and in comparing them with the results obtained by various investigators. The collecting of specimens in

\* Throughout the work on these monographs I am indebted to many individuals and institutions for suggestions, help, and privileges extended to me. Grants from the Horace H. Rackham School of Graduate Studies of the University of Michigan have greatly facilitated both the field and the laboratory studies. My appreciation is expressed particularly to the men who have accompanied me on my numerous expeditions to Alaska, the Yukon Territory, and the Northwest Territories. Much credit is due them for aiding in the collection and care of specimens and for living, at times, under rather difficult circumstances. I am under obligation to Professors T. G. Halle and Gunnar Samuelson, of Naturhistoriska Riksmuseet in Stockholm, with whom I have had the pleasure of association. Thanks are also due to several American institutions and scholars. To the authorities at the New York Botanical Garden, to the staff of the Division of Pathological and Mycological Collections of the United States Department of Agriculture, and to Professor H. H. Bartlett, of the University of Michigan, I am especially indebted.

different seasons and regions, differences in chemicals and formulas for making media and in the duration of the tests, and variations in procedure and the recording of data have all contributed to render the task a large one and often an unsatisfactory one.

The design for the present study has been to formulate as complete a record of the group as is feasible at this time. This necessitated, therefore, the examination of fresh material from all the principal forest types of the continent and collecting in practically every state, province, and territory. An effort was made to do work in areas for which there were few or no records. Nevada, Utah, Oklahoma, Rhode Island, New Brunswick, the Northwest Territories, the Yukon, and Alaska may be cited as specific examples.

Many American fungi were taken to Europe and compared with types, cotypes, and important specimens deposited in European herbaria, especially in the Scandinavian countries. The Berkeley collections at Kew Gardens, London, Romell's specimens at the Naturhistoriska Riksmuséet, the Bresadolan plants at Stockholm, the specimens at Uppsala, the Karsten herbarium at Helsingfors, and the Persoon collections at Leiden received special attention during two visits to the continent. Studies were made in several other herbaria, such as those at Leningrad and Edinburgh. Field work on the fungi involved excursions chiefly in England and Scotland, Norway, Sweden (including Swedish Lapland), Denmark, Finland, Russia, Germany, France, Switzerland, and Czechoslovakia. The areas about Stockholm and Uppsala received special attention. Specimens deposited in the leading American herbaria have been studied.

The present paper discusses ten species of fungi and describes one new resupinate polypore. A comprehensive treatment of the resupinate polypores of North America is planned.

The color terms enclosed in quotation marks are those of R. Ridgway, *Color Standards and Color Nomenclature* (1912).

*Polyporus trichomallus* Berk. & Mont., Ann. Sci.  
Nat., III, 11 : 238. 1849

(Plate I)

*Funalia trichomalla* Pat., Tax. Hymén., p. 95. 1900.

*Trichaptum trich(o)m(o)allum* (Berk. & Mont.) Murrill, Bull. Torrey Bot. Club  
31 : 608. 1904.

*Polyporus Perrottetii* Lév. ex Lloyd, 3 : Sec. Finales, p. 63. 1910.

Fructification effused-reflexed, laterally connate, sometimes resupinate and often covering the entire under surface of logs, reflexed parts 3–12 mm., 1–10 × 5–20 (or more) × 5–12 mm.; surface fuliginous “drab” to almost black, sometimes zonate, conspicuously covered with long intricately interwoven hairs that are approximately 37–100  $\mu$  in diameter; margin thin, sterile below, “avellaneous,” loosely fibrous and darker above, the entire fruiting body, except the tubes and the thin layer to which they are attached, composed of the loose branched fibers; tubes short, mostly 1–2 mm. long, avellaneous within, mouths angular, sometimes daedaloid, about 0.5–2 mm., mostly 0.5–1, edges thin, entire, “wood brown,” “avellaneous,” to “mummy brown,” soon becoming lacerate or irpiciform; spores not seen; hyphae of the intricately woven hairs long, flexuous, nonseptate, brownish, 2–4  $\mu$  in diameter, hyphae of the tube layer hyaline to mostly faintly brown, rarely branched, 2–3  $\mu$  in diameter.

*Allied species.* — *Polyporus trichomallus* may be confused with *Trametes hydroides* since both species are characterized by long intricately branched hairs on the surface. *Pol. trichomallus* is a felty, pliable plant with large irregular pore mouths, whereas *T. hydroides* is more rigid, and the pore mouths are smaller and regular. The context and pores are more brownish gray than the definitely brown context and pores of *T. hydroides*. The surface hairs often disappear in age in *T. hydroides*, but they remain in *Pol. trichomallus*.

*Habitat.* — *Casurina equisetifolia*, *Persea borbonica*, *Populus deltoides*.

*Distribution.* — Florida, Texas.

*Remarks.* — Lloyd states that this plant was named *Polyporus Perrottetii* by Lévillé. Later Montagne described the plant as *Pol. trichomallus* “from the same collection, and everyone without exception since has used Montagne’s name, notwithstanding that all legal authority provides to the contrary” (5). The name *Pol. trichomallus* has become so well established that nothing is to be gained by changing to *Pol. Perrottetii*.

*Polyporus amorphus* Fr., Syst. Myc., I:364. 1821

*Polyporus irregularis* (Sow.) Romell ex Murrill, in Mycol., 10:109. 1918.

*Tyromyces amorphus* (Fr.) Murr., Mycol., 10:109. 1918.



Fructification thin, tough and pliant when fresh, sessile, effused-reflexed,  $0.6 \times 1.3 \times 0.1-0.3$  cm., or resupinate; surface white to gray, "pale cinnamon drab," tomentose or villose-pubescent; margin thin, sterile below; tubes flesh color to orange or red, i.e. "vinaceous buff," "apricot buff," "apricot orange," "hazel," appearing somewhat resinous or waxy, 1-2.5 mm. long; mouths angular, concolorous with the tubes, 2-5 to a mm.; basidia 3-4  $\mu$  in diameter; spores  $3.5-5 \times 1-2 \mu$  (Lowe); cystidia none; hyphae rarely or not much branched, 3-5  $\mu$ .

*Allied species.* — *Polyporus amorphus* may be confused with *Pol. dichrous* because the tubes may appear somewhat waxy or resinous. The mouths are larger in *Pol. amorphus*, being 2-4 to a mm., whereas in *Pol. dichrous* they are 5-7 to a mm. The hymenium of *Pol. amorphus* does not peel off in a thin smooth layer in fresh specimens.

*Habitat.* — *Abies balsamea*, *A. grandis*, *Picea Engelmannii*, *P. sitchensis*, *Pinus attenuata*, *P. contorta*, *P. echinata*, *P. monticola*, *P. ponderosa*, *P. pungens*, *P. rigida*, *P. Strobus*, *P. taeda*, *Pseudotsuga taxifolia*, *Sequoia sempervirens*, *Tsuga canadensis*.

*Distribution.* — California, Idaho, Maine, Montana, North Carolina, Oregon, Pennsylvania, South Carolina, South Dakota, Virginia, Wyoming.

*Occurrence.* — *Polyporus amorphus* attacks the sapwood of coniferous logs and is reported on fallen pine needles (6). It infects only a small number of woods. It can be seen from the list of species presented here that pine is a common substratum.

*Decay.* — The rot of the sapwood of *Pinus rigida* caused by *Polyporus amorphus* has been described by Overholts. The infected wood first changes from its usual light color to "cinnamon buff." Finally, a stringy rot is formed which is characterized by elongated cavities and bands of wood. The elongated cavities represent the spring wood that is destroyed before the summer wood disappears. This separation of spring and summer wood results in the formation of concentric rings. They do not coincide entirely with the annual rings, but the annual rings are split into their two growth areas, spring and summer wood. The rotted wood may be readily separated into narrow strings or strands when twisted. When dry, the rotted wood is brittle and snaps under light pressure. Sheets of mycelium do not develop in the cavities, and no spots or colored lines of any kind are present in the decayed wood (6).

*Polyporus compactus* Overh., Bull. Torrey Bot. Club,  
49 : 170. 1922

Specimens observed :

*Polyporus compactus* Overh. on *Quercus alba*, Lakeland, Michigan.

*Polyporus compactus* Overh. on *Quercus*, Pa. Det. John Stevenson. Herb.  
Mycol. Coll., Bureau Plant Industry, Washington, D.C.

Fructification nodulose, resupinate, effused up to 15 cm., whitish, watery to corky, 3–8 mm. thick, disagreeable odor; pileus, if present, not more than 1 cm. broad and 1.5 cm. thick (Overh.); tubes less than 2 mm. long, frequently lacking or poorly formed; mouths averaging 4 to a mm., basidia large, pyriform, 9–10  $\mu$  in diameter; basidiospores ellipsoid or ovoid, hyaline 7.5–9  $\times$  4.5–6  $\mu$ ; chlamydospores 6–7.5  $\mu$ , abundant on the hymenium and formed singly on the context hyphae, subglobose to broadly ellipsoid, colorless or slightly greenish or yellow under the microscope, 7.5–9  $\times$  6–7.5  $\mu$ ; cystidia mixed with the basidia as narrow, pointed flask-shaped structures, 3–4  $\mu$  in diameter; hyphae of two types: (a) large, hyaline, unstaining, frequently thick-walled, 3–5  $\mu$  in diameter; (b) small, staining and much branched, with a few clamp connections, 2–3.5  $\mu$ .

*Habitat.* — *Quercus alba*.

*Distribution.* — Michigan, New Jersey, Pennsylvania.

*Occurrence.* — Rare. On standing dead trunks or on stumps, especially on *Quercus alba*.

*Cultures.* — Features of *Polyporus compactus* have been obtained in culture by Davidson, Campbell, and Vaughan (3). The growth of the fungus is moderately rapid, forming a radius of 30 to 35 mm. in seven days. The mat exhibits a white, appressed, compacted, tough, thin felty growth, usually with nodulose patches and yellowish, guttulate, abortive poroid areas either scattered or forming a wide circle about the center. These areas are composed of dense masses of chlamydospores and only occasionally produce basidia and basidiospores. A positive oxidase reaction is given by the fungus, which indicates that it causes a white rot.

The fungus exhibits prominent clamps. Chlamydospores in culture are ellipsoid to barrel-shaped, 9–12  $\times$  6–9  $\mu$ ; basidiospores rare, hyaline, truncate, 6–9  $\times$  4–6  $\mu$ .

The optimum temperature for growth has been determined to be approximately 30°C.

*Decay.* — A white heartrot is produced.

*Remarks.* — The description of the fruiting body presented here is based upon that given by Overholts.

The peculiarities of the fruiting body, however, can be demonstrated in pure culture. In culture it is usually entirely resupinate and is composed of a mass of chlamydospores. Pores are poorly formed, and basidia and basidiospores are difficult to locate. In culture abortive yellowish poroid areas develop in both petri dishes and test tubes. This poroid tissue is composed of masses of chlamydospores identical in size and shape with those found in the normal fruiting body (3).

*Poria Bracei* Murr., *Mycologia*, 13:91. 1921

Type and important specimens examined:

*Poria Bracei.* Type. Nassau, New Providence, Bahamas, 1918, L. J. K. Brace. No. 9594, covering under surface of the bottom of a barrel. Herb. New York Botanical Garden, New York.

*Poria Bracei.* Murr. 1427. Rio Piedras, Puerto Rico, Feb. 22, 1914. J. R. Johnston & J. A. Stevenson. Herb. New York Botanical Garden, New York.

*Poria Bracei.* Dade County, Florida, J. S. Stevenson. Det. J. R. Weir, 1913. Herb. Mycol. Coll., Bureau Plant Industry, Washington, D.C.

*Poria Bracei.* Murr., near Miami, Florida, Dow V. Baxter, Sept. 29, 1944. Herb. Dow V. Baxter, Ann Arbor.

Fructification widely effused for as much as 75 cm. and covering the exposed wood surface or decayed organic matter in a felty mat reviving from year to year and forming a mat up to 3 mm. or more in thickness; margin conspicuous, membranous, persistent, wine-colored to lilac; context conspicuous, concolorous with the mouths, mostly 0.5 mm. thick; tubes mostly 0.5 to 1.5 mm. long each season; mouths "fawn color," "cinnamon drab," to "drab gray," 5-6 to a mm., edges entire; spores globose, hyaline 4  $\mu$  (Murr.).

*Allied species.* — There are no species closely allied to this conspicuous plant in North America. It should be pointed out that *Polyporus Bracei* Murr. (*Mycologia*, 11 [1919]:222) is not the same plant, for it has a stipe and a different color and is not at all related.

*Habitat.* — On hardwood logs and decayed organic matter.

*Distribution.* — Florida. Also known from the Bahamas and Puerto Rico.

*Occurrence.* — This unusual poria was discovered first in North America by John Stevenson in Dade County, Florida. I made

collections of it in the same general locality thirty years later, in 1944.

*Trametes hydnoides* (Sw.) Fr., *Epier.*, p. 490

*Boletus hydnoides* Sw., *Prodr.*, 149. 1788; *Fl. Ind. Occid.*, 3: 1924. 1806.

*Boletus hydnatinus* Bose, *Ges. Nat. Freunde Berlin Mag.*, 5: 84, pl. 4, fig. 3. 1811.

*Polyporus pellitus* G. Meyer, *Fl. Esseq.*, p. 304. 1818.

*Boletus crinitus* Spreng., *Sv. Vet., Acad. Hydl.*, 1820: 51. 1820.

*Boletus fibrosus* Hook. in Kunth, *Syn. Pl.*, 1 (10). 1822.

*Trametes ocellata* Berk. & Curt., *Journ. Linn. Soc.*, 10: 319. 1868.

*Polyporus Feathermanni* Rav., *Grevillea*, 6: 130. 1877.

*Pogonomyces hydnoides* (Sw.) Murr., *Bull. Torrey Bot. Club*, 31: 609. 1904.

Important specimen:

*Polyporus Feathermanni* Rav., Gainesville, Florida. *Fungi Americani Exsiccati*.

H. W. Ravenel. Herb. New York Botanical Garden, New York.

Fruetification sessile, often imbricate,  $3-5 \times 5-10 \times 0.5-1$  cm. (Murr.); surface zonate, "army brown," "bone brown" to nearly black, conspicuously covered with rigid branched fibers, which often disappear with age; margin entire or undulate, sterile below; context brown, fulvous, zonate, corky, 3-5 mm. thick; tubes mostly about 5 mm. long; mouths mostly circular 3-4 to a mm. "Prout's brown," "mummy brown" to blackish; dissepiments thick, entire; spores oblong, smooth, hyaline,  $8-10 \times 3-4 \mu$ ; no cystidia.

*Allied species.* — *Trametes hydnoides* is not a resupinate polypore, but because it may be confused with *Polyporus trichomallus* (which is often resupinate or effused-reflexed), it is included in this series. Both species are characterized by long intricately branched hairs on the surface. *T. hydnoides* is not felty and pliable, as is *Pol. trichomallus*. *T. hydnoides* is corky, as are most temperate-zone species of *Polystictus*, but, unlike felt, is not pliable. The pore mouths of *T. hydnoides* are small and regular, whereas those of *Pol. trichomallus* are relatively large and irregular. The context of *T. hydnoides* is definitely brown; that of *Pol. trichomallus* is gray brown. The surface hairs often disappear in age in *T. hydnoides*, but they remain in *Pol. trichomallus*.

*Habitat.* — *Acacia aurifera*, *Carya pecan*, *Casurina equisetifolia*, *Celtis* sp., *Chrysobalanus* sp., *Citrus aurantifolia*, *Damburneya catesbyana*, *Ficus brevifolia*, *Fraxinus berlandieriana*, *Gleditsia* sp., *Juglans nigra*, *Leucaena glauca*, *Liquidambar styraciflua*, *Magnifera indica*,

*Platanus* sp., *Prosopis juliflora*, *Prunus persica*, *Quercus myrtifolia*, *Q. Phellos*, *Q. virginiana*, *Taxodium distichum*, *Trema mollis*, *Ulmus* sp.

*Distribution.* — Florida, Louisiana, Mississippi, Texas.

*Occurrence.* — *Trametes hydnoides* is more abundant in Florida than elsewhere in North America, but is not uncommon in Texas and Louisiana. It appears to be rare in Mississippi and is not known from any of the other states.

*Cultures.* — Isolated by Davidson, Campbell, and Blaisdell (2), who report that it gives a positive reaction to tannic acid media.

*Poria zonata* Bres., *Mycologia*, 17:77. 1925

Type:

*Poria zonata* Bres. on *Abies grandis*, Priest River, Idaho. Coll. & det. James R. Weir. Ex 71007, Herb. Mycol. Coll., Bureau Plant Industry, Washington, D.C. New York Botanical Garden, New York.

Fructification broadly effused, white; margin sterile; subiculum membranaceous, 0.5 mm. wide; tubes 1–3 mm. long; mouths irregular, 1–2 to a mm.; basidia 18–20  $\times$  3.5–4.5  $\mu$ ; spores hyaline, cylindrical-curved, biguttulate, 5–6  $\times$  2–2.5  $\mu$ ; hyphae 2–4  $\mu$ ; cystidia 45–46  $\times$  15–18  $\mu$ .

*Allied species.* — *Poria zonata* suggests *P. ambigua*, but may be distinguished from it not only because of habitat differences but also because of its conspicuous stereum-like border, and its spores, which are 2–2.5  $\mu$  wide, cylindrical and not obovate, ellipsoid, 3–3.5  $\mu$  wide. The border will also serve as a differentiating feature to separate *P. zonata* from *P. sinuosa*. Furthermore, the spores of *P. sinuosa* (a form of *P. vaporaria*) are only 1–2  $\mu$  wide.

*Habitat.* — *Abies grandis*.

*Distribution.* — Idaho.

*Remarks.* — The description is based upon that of Bresadola.

*Poria grandis* Overholts, *Mycologia*, 35:249. 1943

(Plate II)

Part of type:

*Poria grandis* on *Tsuga canadensis*, 71421 Herb. Mycol. Coll., Bureau Plant Industry, Washington, D.C.

Fructification effused, soft-membranaceous, separable, at first entirely pale sulphur yellow, the sterile margin and subiculum re-

maining so in dried specimens, elsewhere pale avellaneous or grayish on drying, with small yellowish mycelial strands that penetrate the rotten substratum; subiculum tissue evident, soft, tough, yellow; tubes not more than 1 mm. long, yellow within, the pore surface at first pale yellow, whitening at maturity, but on drying becoming isabelline, the pores obliquely gaping or more regular, angular, thin-walled, entire, averaging about 3 per mm.; spores ellipsoid to broadly ellipsoid, smooth, hyaline,  $3-4 \times 2-3 \mu$ ; no cystidia; hyphae of subiculum  $3-4.5 \mu$  in diameter, all thin-walled, septate, and clamped.

*Allied species.* — This membranaceous, rather soft species suggests *Poria mollusca* as known by contemporary students in Sweden. The more or less pale yellow color and the soft appearance are similar to those of many specimens I have collected in that country. If, however, a specimen of *P. grandis* is collected that is fruiting readily, the plant may possibly suggest an immature *Poria subacida* Pk. The mycelial strands, the generally membranous nature of the fungus, and the relatively short tubes serve as features by which *P. grandis* may be separated from *P. subacida*. Because *Poria subacida* causes much butt rot in northern coniferous swamps on trees other than cedar and is also believed to be a possible cause of decay in *Thuja occidentalis*, the finding of a closely allied polypore on cedar may make difficult diagnoses of decay alone.

*Habitat.* — *Thuja occidentalis*, *Pinus flexilis*, *Tsuga canadensis*.

*Distribution.* — Michigan, Minnesota, New Mexico, Tennessee.

*Polystictus cinnabarinus* (Jacq.) Sacc.,  
Syll. Fung., 6: 245. 1888

*Boletus cinnabarinus* Jacq., Fl. Austr., 4: 2. 1776.

*Boletus coccineus* Bull., Herb. Fr., p. 364. 1791.

*Polyporus cinnabarinus* (Jacq.) Fr., Syst. Myc., 1: 371. 1821.

*Trametes cinnabarinus* (Jacq.) Sacc., Syll. Fung., 6: 245. 1888.

*Pycnoporus cinnabarinus* (Jacq.) Karst., Rev. Myc., 3: 18. 1881.

Fructification corky to rigid, dimidiate,  $1-5 \times 2-10 \times 0.5-2$  cm., or sometimes resupinate, surface azonate, tomentose to glabrous, "light salmon orange," "vinaceous rufous," "apricot orange," "Mars orange," "vinaceous tawny," margin thin, acute, sterile below; context concolorous, 0.1-2 cm. thick; tubes concolorous

with context, 1–4 mm. long, mouths brick red or orange, “apricot orange,” “vinaceous rufous,” 2–4 to a mm.; spores hyaline to yellowish, cylindric,  $5-7 \times 2-3 \mu$  (Shope); no cystidia, hyphae of the context seldom branched, thick-walled, 4–8  $\mu$  in diameter.

*Allied species.* — This species is closely allied to even more colorful *Polyporus* (*Trametes*) *sanguineus* (L.) Fr., and Weir (6) suggests that they may be identical. One might well consider *Pol. cinnabarinus* a northern form of *Pol. sanguineus* because of certain differences here noted. It is seldom, if ever, substipitate, but *Pol. sanguineus* is characteristically so; it is a thicker plant, usually being 5 mm. thick, whereas *Pol. sanguineus* is less than 3 mm. thick; it is a less brilliant red, i.e. “apricot yellow” or “Mars yellow,” in contrast to the “flame scarlet” or “English red” that are customary for *Pol. sanguineus*.

Because the names are well known and have so frequently appeared in the literature, for the time being it is not believed necessary to establish a new variety until it can be demonstrated that the two are distinct in culture.

*Habitat.* — *Abies balsamea*, *Acer glabrum*, *A. rubrum*, *A. saccharum*, *Betula fontinalis*, *B. glandulosa*, *B. lenta*, *B. lutea*, *B. papyrifera*, *B. papyrifera occidentalis*, *Castanea dentata*, *Fagus grandifolia*, *Hicoria ovata*, *Ilex opaca*, *Juglans cinerea*, *Liquidambar styraciflua*, *Liriodendron tulipifera*, *Nyssa sylvatica*, *Picea rubra*, *Pinus caribaea*, *P. edulis*, *P. palustris*, *Populus angustifolia*, *Prunus pennsylvanica*, *P. serotina*, *P. virginiana*, *Quercus alba*, *Q. borealis maxima*, *Q. catesbaei*, *Q. nigra*, *Q. palustris*, *Q. prinus*, *Q. texana*, *Q. ulahensis*, *Q. velutina*, *Q. virginiana*, *Sabal palmetto*, *Salix* sp., *Sassafras officinale*, *Sorbus americana*, *Thuja plicata*, *Tilia americana*, *Tsuga canadensis*, *Ulmus americana*.

*Distribution.* — British Columbia, Manitoba, Ontario, Quebec, Yukon Territory, Alaska, Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming (44 states).

*Poria limitata* (Berk. & Curt.) Cooke 14:113. 1886

(Plate III)

*Polyporus limitatus* Berk. & Curt., Berk., Grevillea, 1:54. 1872.

Important specimens observed:

*Poria limitata* Langlois, Louisiana. Herb. New York Botanical Garden, New York.

Fructification annual or perennial, appearing in more or less orbicular or elongated, somewhat coriaceous patches not uncommonly about  $3 \times 5$  cm., but usually about  $1.5 \times 4$  cm., mostly on bark of standing trees; inseparable to separable; margin often conspicuous as on undulating border, tomentose, sterile, whitish or "pale pinkish buff," 0.5 to 3.5 mm., mostly 0.5 mm. wide; subiculum "pinkish buff," mostly less than 0.3 mm. thick; tubes up to 1.5 mm. long each season, mostly 1 mm. long; mouths whitish, "pale pinkish buff" to "pinkish buff," circular, thick-walled, entire, 4-5 to a mm.; basidia mostly two-spored, spores hyaline, smooth, somewhat angular, ovoid,  $5.5-7(8) \times 5.5-7 \mu$ ; no cystidia, or sometimes cystidium-like structures (hyphal pegs?) present; hyphae or the hymenium thin, narrow, much branched, 1-3, mostly  $2 \mu$  wide; without clamp connections.

*Allied species.* — *Poria limitata* suggests *P. unita* because of the somewhat coriaceous fruiting bodies, their color, and the thick-walled entire mouths of the tubes. It is not, however, widely effused over the substratum (which in *P. unita* may often be decorticated). It appears in small patches over the bark of standing tree trunks and often on the dead branches of living trees. Without a close examination the numerous small fruiting bodies on the bark may even remind one of those of *Aleurodiscus oakesii*.

*Poria unita* occurs on many different types of substrata and is widely distributed throughout the continent. *P. limitata* is found chiefly on oak and is mostly a southern species.

*Habitat.* — *Quercus virginiana*.

*Distribution.* — Florida, Mississippi, New Jersey, South Carolina.

*Occurrence.* — Most porias grow on fallen logs or on decorticated wood in the forest or on structural timbers and other wood products. *Poria limitata* appears usually on the bark of standing live oaks throughout the Gulf states and the southeastern coastal



regions. It usually thrives wherever the live oak and closely related species of oak occur.

*Remarks.* — Bresadola found to be sterile the specimen from the Berkeley Herbarium that I saw at Kew. This specimen bore some resemblance to *Poria papyraceae* (Schw.) Cooke, since the mouths were rather large, i.e. 3–4 to a mm. *P. papyraceae* is mostly a conifer-inhabiting fungus.

### ***Poria viridiuscula*, sp. nov.**

(Plates IV–V)

Type:

*Poria viridiuscula*, sp. nov., on *Liriodendron tulipifera*, Athens, Georgia. October 3, 1944. Coll. Dow V. Baxter and Lyle Jackson. Herb. Dow V. Baxter, Ann Arbor.

Planta resupinata, cum fructificatione annua, late effusa vel sequens rimas corticis usque ad 5 m., crassitudine minus quam 3 mm., viridiuscula, albida, vel salmonicolor, aliquando nitida, siccitate saepe tenuem subtranslucentem membranosam laminam formans; margine interdum 15 mm. lata sed plerumque 2–3 mm.; tubis plerumque circa 2 mm. longis, sed si siccis solum 0.3 mm., vel brevioribus 4–5 per mm.; sporis 3–4  $\mu$  longis, 1–2  $\mu$  latis; hyphis hyalinis, 2–5.5  $\mu$  crassis, plerumque 2–2.5  $\mu$ . Cystidia desunt. Specimen typicum legerunt Dow V. Baxter et Lyle Jackson, Athenis, Georgia, Oct. 3, 1944; in herbario auctoris conservatum, sub numero AZ 23156.

Fructification annual, resupinate over large areas or following the crevices of the bark for as much as 5 meters, effused for approximately 5 meters; when fresh "ivory yellow," "marguerite yellow," "pale olive buff" to "olive buff," drying to "buffy citrine" or "dark olive buff" to "mummy brown," at first up to 3 mm. thick, but drying to a thin skinlike glassy surface that does not resemble the fructification of the fresh poria in color or texture; margin up to 15 mm. or more, but mostly 2–3 mm. wide, conspicuous in dried material; tubes mostly about 2 mm. long in fresh plants, but drying to 0.3 mm., mostly less in herbarium specimens and becoming somewhat translucent; mouths 4–5 to a mm., appearing translucent in dried plants; spores 3–4  $\times$  1–2  $\mu$ , hyphae hyaline, 2–5.5  $\mu$ , mostly 2–2.5, in diameter, no cystidia.

*Allied species.* — Fresh growing plants appear entirely different from

dried specimens. This conspicuous whitish poria, which soon becomes faintly pale greenish or "pale olive buff," does not closely resemble any of the whitish porias when fresh. The distinct cystidia which are present in *Poria corticola* are not found in *P. tacamahacae* Baxter. Thus fungus is recognized by its pale greenish white pore surface when fresh, and it, too, may dry to a thin skinlike sheet. The tubes of *P. tacamahacae* are longer in the dried plants, and herbarium material is of a different color. *P. tacamahacae* is more yellowish, i.e. "cream buff," "colonial buff"; in thick specimens, however, it is sometimes red brown, i.e. "Verona brown." In culture *P. viridiuscula* does not exhibit the pronounced glassy appearance characteristic of *Poria tacamahacae*.

In some herbaria this plant may possibly be found under the name of "*Poria vitreus*." Donk (4) had described the spores of *P. (Podoporia) vitrea* Fr. non Pers. as globose 4.25–5  $\mu$  and under that species lists as synonyms "*Pol. undatus* Pers. Myc. Eur. 2: 90 (t. 16 f. 3), 1895; Lloyd Syn. Apus Pol. 321 (f. 662, 663), 1915; *Poria undata* (Pers.) Bres. in Ann. Myc. 1: 78, 1903; Bourd. et Galz." I have seen no evidence in Holland or in Sweden that this plant from Georgia should be called *Pol. vitreus*. The spores of the Georgia plant should readily separate it from the one Donk records. This collection emphasizes, however, the need for an understanding of the fresh plant since in the fresh state this poria is much different from the dried material. Only herbarium specimens might be confused with *P. vitreus*.

*Habitat.* — *Aesculus glabra*, *Liriodendron tulipifera*.

*Distribution.* — Georgia, Tennessee.

*Cultures.* — Isolated from *Liriodendron tulipifera*, Athens, Georgia.

*Poria viridiuscula* grows readily on malt-extract agar and produces tubes within two weeks in petri-dish cultures. The colors that it exhibits in nature, however, are not distinct in such tests. The olive or pale green appearance, i.e. "pale olive buff" to "olive buff," is evident when *P. viridiuscula* is grown on either red-gum or white-pine blocks. A thin whitish mycelial growth covers such blocks within three months, but it does not mask the shape of the test pieces within that time. Tubes are formed on both agar and wood blocks; and on the blocks they first appear as nodules. Fructification occurs on both conifers and hardwood.

A conspicuous white rot, marked by shrinking and collapsing of both red-gum and white-pine test pieces, results after a one-year inoculation period. The rate of decay is approximately the same in both types of wood.

Cultures of *Poria viridiuscula* grow equally well in the light and the dark. This plant belongs to the "rapid-growth" class of porias since it fills the petri dish within a seven-day period at the temperature for best growth. Tests for growth at temperatures below 25°C. have not been made, but *P. viridiuscula* develops rapidly at both 25°C. and 30°C. Growth is retarded rapidly at 35°C. There is almost no growth within seven days at this temperature and only approximately 20 mm. within a two-week period.

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*Polyporus trichomallus* on *Persea borbonica*. Miami, Florida



BAXTER

PLATE II



*Poria grandis* on *Tsuga canadensis*. No. 71421, Mycological Collections,  
Bureau of Plant Industry, Washington, D.C.





*Poria limitata*, substratum unknown, California







*Poria viridiuscula*, sp. nov., on *Liriodendron tulipifera*, Athens, Georgia. Herbarium specimen





*Poria viridiuscula*, sp. nov., isolated from *Liriodendron tulipifera* and growing on test blocks of *Liquidambar Styraciflua*. The living plant differs from dried specimens in color, thickness, lack of glassy skinlike appearance, and absence of a conspicuous margin



PAPERS OF THE  
MICHIGAN ACADEMY OF SCIENCE  
ARTS AND LETTERS

EDITORS

EUGENE S. McCARTNEY  
HENRY VAN DER SCHALIE

VOLUME XXXII (1946)  
PART I: BOTANY AND FORESTRY

"Pusilla res mundus est nisi in illo  
quod quaerat omnis mundus habeat."

— SENECA, *Naturales Quaestiones*

ANN ARBOR: THE UNIVERSITY OF MICHIGAN PRESS  
LONDON: GEOFFREY CUMBERLEGE, OXFORD UNIVERSITY PRESS

1948

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Set up and printed,  
July, 1948

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# BOTANY



# INTERESTING SPECIES OF VASCULAR PLANTS COLLECTED IN WESTERN MICHIGAN

CLAYTON W. BAZUIN

**T**HE following list of vascular plants represents the species and varieties collected in Michigan in the eight years from 1938 to 1945, inclusive. So far as I have been able to learn, the species here listed have not previously been reported for the western part of the state. To determine the distribution the herbaria of the University of Michigan, Michigan State College, Aquinas College, University of Notre Dame, the Chicago Museum of Natural History, and the private collection of C. R. Hanes, Schoolcraft, Michigan, were studied or consulted. All available publications were searched so as to be sure that each species is either rare or new for western Michigan. The numbers after the locality citations are my collection numbers. Unless otherwise noted, the records are based upon my own collections.

My determinations of species have been checked by the following authorities: J. R. Swallen for Gramineae; F. G. Hermann for *Carex* and *Juncaceae*; Mrs. B. R. Clarke for aquatics, asters, and *Solidago*; H. K. Svenson for *Eleocharis*.

Specimens are preserved in my herbarium and in those of the following institutions: the University of Michigan, Ann Arbor, Michigan; Michigan State College, East Lansing, Michigan; Aquinas College, Grand Rapids, Michigan; the Cranbrook Institute of Science, Bloomfield Hills, Michigan; the Chicago Museum of Natural History, Chicago, Illinois; the Brooklyn Botanical Garden, Brooklyn, New York; Harvard University (Gray Herbarium); and the National Museum, Washington, D.C.

## LIST OF SPECIES

**BOTRYCHIUM MULTIFIDIUM** (Gmel.) Rupr. var. **SILAIFOLIUM** (Presl)  
Broun. — A very rare fern. Its rarity may be due to its appear-

ance late in the summer. Low wet woods on north side of Camp Lake, Kent Co., no. 2198, Sept. 29, 1942; densely wooded ravine, Grand Rapids Township, Section 2, Kent Co., no. 6015, April 4, 1944; boggy meadow, Robinson Township, Section 35, Ottawa Co., no. 5137, Sept. 18, 1943.

**BOTRYCHIUM SIMPLEX** Hitchcock. — A rare fern; found by Mr. Charles Nelson on the boggy border of Black Ash Swamp, south of Grand Rapids, Byron Township, Section 13, Kent Co., 1939.

**POLYPODIUM VIRGINIANUM** L. — Much more abundant than the records indicate, especially in the dunes of Lake Michigan. Wooded slopes, Bostwick Lake region, Kent Co., Charles Nelson, 1938; dunes near Stony Lake, Oceana Co., no. 4747, July 4, 1942; wooded slopes on shore of Pigeon Lake, Ottawa Co., no. 5824, Sept. 8, 1943; Macatawa Park, Ottawa Co., no. 1809, July 30, 1940; dune slopes, Leeland, Leelanau Co., Sister M. Marcelline Horton, Aquinas College, Grand Rapids.

**ISOETES LACUSTRIS** L. — Apparently very rare, since this is the only *Isoetes* I have ever collected. In shallow water on south side of Soft Water Lake, Grand Rapids, Kent Co., no. 619, Aug. 4, 1939.

**POTAMOGETON CRISPUS** L. — A European species slowly spreading in the Great Lakes. Abundant in Reed's Lake, East Grand Rapids, Kent Co., no. 941, 1939; Pickerel Lake, Kent Co., no. 2435, July 7, 1940; Pigeon Lake, Port Sheldon, Ottawa Co., no. 939, Aug., 1939; Spring Lake, Ottawa Co., no. 3020, June 21, 1941.

**POTAMOGETON FILIFORMIS** Pers. var. **BOREALIS** (Raf.) St. John. — Abundant in Spring Lake, Ottawa Co., Charles Nelson, no. 3023, June 6, 1941; Bill's Lake, Newaygo Co., no. 3387, July 12, 1941.

**POTAMOGETON GRAMINEUS** var. **GRAMINIFOLIUS** f. **MYRIOPHYLLUS** (Robbins) House. — Frequent in many lakes of western Michigan. Sandy Bottom Lake, Kent Co., no. 3388, July 7, 1941; Pine Lake, Kent Co., no. 1677, July 18, 1940; Long Lake, Ionia Co., no. 3150, June 30, 1941; Duck Lake, Muskegon Co., July 7, 1941.

**POTAMOGETON INTERRUPTUS** Kitaibel. — A rare pond weed; a single station, Bostwick Lake, Kent Co., no. 943, Nov. 28, 1939.

**POTAMOGETON BERCHTOLDII** var. **POLYPHYLLUS** Morong. — A variation of the very common *P. pusillus* L. Common in Reed's Lake, Kent Co., no. 816, Aug., 1939; Camp Lake, Kent Co., no. 951,

Aug. 4, 1939; Soft Water Lake, Kent Co., no. 673, Aug. 16, 1939; Thomas Lake, Kent Co., no. 2430, Aug. 3, 1941; Little Pine Island Lake, Kent Co., no. 2431, Aug. 10, 1941; Duck Lake, Muskegon Co., no. 3195, July 7, 1941; Bill's Lake, Newaygo Co., no. 3387, July 12, 1941.

POTAMOGETON ROBBINSII Oakes. — Occurs in many lakes of western Michigan. H. J. Oosting, *Pap. Mich. Acad. Sci., Arts, and Letters*, Vol. 15 (1931), reports it as rare, with stations in Muskegon and Ottawa counties. Abundant in Camp Lake, Kent Co., no. 2606, July, 1939; Crooked Lake, Kent Co., no. 5090, Aug. 10, 1942; Ratigan Lake, Kent Co., no. 2607, July, 1939; Big Pine Island Lake, Kent Co., no. 2608, July 10, 1939; abundant in Kimball Lake, Newaygo Co., no. 3567, July 22, 1941.

POTAMOGETON STRICTIFOLIUS var. RUTILOIDES Fern. — A single station, Green Lake, Allegan Co., no. 3051.

POTAMOGETON ALPINUS Balbis var. TENUIFOLIUS (Raf.) Ogden. — Distribution general; previously reported in western Michigan by H. J. Oosting, *loc. cit.* Two new stations: Lime Lake, Kent Co., no. 1805, July 29, 1940; Wabasis Creek, Kent Co., nos. 3278-3282, July 11, 1941.

POTAMOGETON VASEYI Robbins. — A very rare form, abundant in Pine Lake, Kent Co., no. 1676, July 17, 1940; Scram Lake, Kent Co., no. 6119, July 29, 1944.

NAJAS MARINA L. — Brook's Lake, Newaygo Co., no. 2293, Aug. 3, 1940. So far as is known, the occurrence of this plant in Michigan is restricted to this station.

ALISMA PLANTAGO-AQUATICA var. PARVIFLORUM (Pursh) Farwell. — Occasional in western Michigan; stations at Pine Lake, Kent Co., no. 2188, Sept. 4, 1941.

ALISMA PLANTAGO-AQUATICA L. var. BREVIPES (Greene) Samuelson. — Wet sand along M-16, near Mona Lake, Muskegon Co., no. 3210, July 7, 1941.

SAGITTARIA CRISTATA Engelm. — Not abundantly reported. Three new stations were discovered in 1944-45: Crystal Lake, Newaygo Co., no. 3993, Aug. 28, 1941; Scram Lake, Kent Co., no. 6121, July 20, 1944; Provemont, Lake Leelanau, Leelanau Co., no. 6321, Aug. 29, 1944.

TYPHA ANGUSTIFOLIA L. — Not listed for Kent Co. by E. J. Cole, *Flora of Grand Rapids and Vicinity*, 1902. Not abundant.



- Along M-16, near Cascade, Kent Co., no. 44; Bear Creek, Robinson Township, Section 23, Ottawa Co., no. 1644, July 12, 1940.
- XYRIS CAROLINIANA* Walb. — A rare form not previously reported. Shore of Angle Lake, Kent Co., no. 1873, Aug. 3, 1940; wet sandy shore of Twin Lakes, Muskegon Co., no. 5860, Sept. 8, 1943.
- FESTUCA OCTOFLORA* (L.) Beaux. — A single station, Fallasburg Park, Kent Co., no. 920, May 25, 1939.
- FESTUCA OVINA* var. *DURIUSCULA* (L.) Koch. — Abundant in dune fields south of Muskegon along Lake Michigan, Muskegon Co., nos. 4509-4968, May 23, 1942.
- HOLCUS LANATUS* L. — Infrequent in wet marshy places. Springy meadow near Feenville Junction on M-31, Allegan Co., no. 4977, Aug. 4, 1942; East Grand Rapids, Kent Co., no. 6500, July 10, 1945.
- MUHLENBERGIA UNIFLORA* (Muhl.) Fern. — Boggy marsh along M-31 in Fife Lake Forest, Grand Traverse Co., no. 3783, Aug. 14, 1941.
- PANICUM AGROSTOIDES* Spreng. — Wet sand along M-16, west of Nunica, Ottawa Co., no. 5079, Aug. 8, 1942.
- PANICUM ASHEI* Pearson. — Small clumps, in dry oak woods near Grand Haven, Pottawattomie Bayou, Ottawa Co., no. 1349, May 25, 1939.
- PANICUM DEAMII* Hitchc. & Chase. — A rare grass, first discovered by C. C. Deam in Indiana. Dr. Jason Swallen, of the National Museum, informs me that the specimens taken at Stony Lake, Oceana Co., nos. 4727, 4784, July 4, 1942, are the first for Michigan.
- PANICUM LINDHEIMERI* Nash. — Wet sand on shore of Dean Lake, five miles northeast of Grand Rapids, Kent Co., no. 5146, Oct. 10, 1942; wet sand along M-16, west of Nunica, Ottawa Co., no. 5078, Aug. 19, 1942.
- PANICUM MERIDIONALE* Ashe. — Apparently more common than reported, which may be due to its late appearance. Near shore of Dean Lake, five miles northeast of Grand Rapids, Kent Co., no. 5146a, Aug. 19, 1942; on shore of Twin Lakes, Muskegon Co., no. 5867, Sept. 9, 1943; Crockery Lake, Muskegon Co., no. 5882, Sept. 9, 1943.

- POA PALUSTRIS* L. — Marshy shore of Long Lake, Ionia Co., no. 3137, June 30, 1941; marshy southwestern shore of Stony Lake, Oceana Co., no. 4783, July 7, 1942.
- POA TRIVIALIS* L. — Wet, shady, boggy ravine at Fallasburg Park, Kent Co., no. 4531, June 14, 1942.
- SCHIZACHNE PURPURASCENS* (Torr.) Swallen. — Frequent in dune woods, on the high dunes at Grand Haven, Ottawa Co., no. 4687, June 20, 1942.
- CAREX ANNECTENS* Bickn. — Small clearing in a large beech-maple woods on the west belt line of M-114, Walker Township, Section 19, Kent Co., no. 1481, July 10, 1940.
- CAREX BUXBAUMII* Wahl. — Large marsh on Maryland Farms, M-21, east of Grand Rapids, Kent Co., no. 824, May 28, 1939; Ely Lake, Allegan Co., no. 1155, June 6, 1942; L. Lake No. 1, Lake Co., no. 1320, June 25, 1940.
- CAREX CONCINNA* R. Br. — Sides of steep, heavily wooded dune hills near Lake Macatawa on the Ottawa and Allegan county line, no. 4928, July 14, 1942. First recorded station for western Michigan.
- CAREX CONVOLUTA* Mack. — Numerous throughout southern Michigan. Under trees in wooded ravine at Fallasburg Park, Kent Co., no. 906, May 10, 1939; deep wooded ravine along Scott Creek, Kent Co., no. 1264, June 6, 1940; wooded ravine at Pine Hill, on the Thornapple River, Kent Co., no. 1104, June 17, 1940; low boggy wood, Little Pigeon Creek, Ottawa Co., no. 1388, June 17, 1940; wet woods, Green Lake, Allegan Co., no. 4550, June 18, 1942.
- CAREX CRYPTOLEPIS* Mack. — All specimens found on wet sandy shores. Morgan Lake, Kent Co., no. 1222, June 9, 1942; Pine Lake, Kent Co., no. 1722, July 20, 1940; Omen Lake, Kent Co., no. 1741, July 20, 1940; Blanche Lake, Newaygo Co., no. 2084, Sept. 1, 1940; Bass Lake, Newaygo Co., no. 3698, Aug. 4, 1941; Dumont Lake, Allegan Co., no. 4641, June 27, 1942.
- CAREX CUMULATA* (Bailey) Mack. — Single station in rich alluvial soil of Bass River, where it crosses M-50, Ottawa Co., no. 931, July 7, 1940.
- CAREX CRAWEI* Dewey. — Marshy marly shore of Dumont Lake, Allegan Co., no. 4149, June 27, 1941. Dr. F. J. Hermann informs me that this is the second station for western Michigan. His

only report is for Emmet Co. See his article "The Genus *Carex* in Michigan," *Am. Mid. Nat.*, 25 (1941): 44, map 105.

*CAREX DAVISII* Schwein & Torr. — A rare sedge discovered in the Herbarium of E. J. Cole, Aquinas College; identified by Dr. F. J. Hermann. Indian mounds on Grand River, near Grand Rapids sewage disposal plant, Kent Co.

*CAREX DEBILIS* var. *RUDGEI* Bailey. — Occurs sparingly in southern part of Michigan. Damp woods, Wabasis Lake, Kent Co., no. 1486, July 4, 1940; dune woods along Lake Michigan at Duck Lake, Muskegon Co., no. 3177, July 7, 1941; Brush Lake, Newaygo Co., no. 5384, June 25, 1943; Beaver Island, Emmet Co., no. 2994, May 25, 1942, Sister M. Marcelline Horton.

*CAREX EMORYI* Dewey. — Salt Spring, Pere Marquette Railroad yards south of Grand Rapids, Kent Co., no. 1293, June 6, 1940; Pine Hill, Kent Co., on the Thornapple River at Cascade, no. 2952, June 7, 1941; shore of Stony Lake, Oceana Co., no. 4750, July 7, 1942.

*CAREX EMMONSII* Dewey. — A new station on sandy shore of Ely Lake, Allegan Co., no. 1154, June 6, 1940.

*CAREX FOLLICULATA* L. — Boggy woods on Grand River, Plainfield Township, Section 26, Kent Co., no. 2919, May 30, 1941; boggy woods, Tryone Township, Section 13, Kent Co., no. 4894, July 21, 1942; wet woods, Little Pigeon Creek, Ottawa Co., no. 1346, June 28, 1940; dune woods, Wilderness Park, Grand Haven Township, Section 35, Ottawa Co., no. 1350, June 28, 1940; wet woods, Wetmore Lake, Monterey Township, Allegan Co., no. 4676, June 27, 1942. Since this species is fairly common in rich wet woodlands, it is hard to understand why only a few reports and specimens are available.

*CAREX FOENEA* Willd. — Considered rare some years ago, but new stations have been added until its southern range now extends to Castle Park, Allegan Co. Dune woods, Duck Lake, Muskegon Co., no. 3172, July 7, 1941; dune woods, Ottawa Beach, Ottawa Co., no. 1473, June 28, 1940; dune woods, Castle Park, Ottawa Co., no. 4907, July 14, 1942.

*CAREX INTUMESCENS* var. *FERNALDII* Bailey. — Dense damp woods, Oakfield Township, Section 8, Kent Co., no. 4954, July 22, 1942; wet woods, Little Pigeon Creek, Ottawa Co., no. 914, June 28, 1939; Dumont Lake, Allegan Co., no. 4573, June 27, 1942.

- CAREX JAMESII* Schwein. — A rare sedge from southwest Michigan; reaches its northern limit in the rich low woods near Grand Rapids, on Aquinas College grounds, Kent Co., no. 5287, June 10, 1943; damp woods just west of Green Lake, Allegan Co., no. 4551, June 21, 1942.
- CAREX LAEVIVAGINATA* (Kukenth.) Mack. — All specimens taken in low rich woods. Scott Creek, Kent Co., no. 1269, June 17, 1940; Little Pigeon Creek, Ottawa Co., no. 1598, July 12, 1940; Dumont Lake, Allegan Co., no. 4624, June 27, 1942.
- CAREX LARICINA* Mack. — Abundant on boggy shore of Pigeon Lake, Ottawa Co., no. 1469, July 2, 1940; Black Ash Swamp, Byron Township, Section 13, Kent Co., no. 2801a, May 11, 1941.
- CAREX LONGII* Mack. — Low oak woods along M-50, just west of Pottawattomie Bayou junction, Ottawa Co., no. 1611, July 12, 1940; along M-16, two miles east of Fruitport, Ottawa Co., no. 3233, July 11, 1941.
- CAREX LEPTONERVIA* Fern. — Infrequent throughout western Michigan; three stations given are only ones for counties named. High bluffs at Pine Hill, Thornapple River, Cascade, Kent Co., no. 2314, June 25, 1940; low dune woods, Pigeon Creek, Grand Haven Township, Ottawa Co., no. 541, June 28, 1940; Beaver Island, Emmet Co., May 30, 1942, Sister M. Marcelline Horton.
- CAREX LENTICULARIS* Michx. — Discovered in E. J. Cole's herbarium, Aquinas College; identified by Dr. F. J. Hermann. Along Plaster Creek, Paris Township, Kent Co.; only record for Michigan.
- CAREX LUCORUM* Willd. — Dune woods near Port Sheldon, Ottawa Co., no. 1541, July 2, 1940; dune woods, Duck Lake, Muskegon Co., no. 3174, July 7, 1941.
- CAREX MOLESTA* Mack. — Rich alluvial woods, Indian mounds on Grand River near Grand Rapids sewage disposal plant, Kent Co., no. 1035, July 16, 1940; deep ravine, Big Pine Island Lake, Kent Co., no. 4842, May 5, 1942; rich wooded valley, Grand Rapids Township, Section 25, Kent Co., no. 818, May 28, 1939.
- CAREX ORMOSTACHYA* Wieg. — New western Michigan station; low maple woods, Stony Lake, Oceana Co., no. 4701, July 4, 1942.
- CAREX PECKII* Howe. — Two new stations: Beaver Island, Emmet Co., no. 5181, May 30, 1942; Charlevoix, Charlevoix Co., May 30, 1942, Sister M. Marcelline Horton.
- CAREX PROJECTA* Mack. — Rich moist woods. Pratt Lake, Kent

- Co., no. 4800, June 1, 1942; Aman Park, Ottawa Co., no. 1569, July 10, 1940; Long Lake, Newaygo Co., no. 3877, Aug. 17, 1941; Dorr, Allegan Co., no. 4575, June 29, 1942.
- CAREX RICHII* (Fern.) Mack. — Rare; only other station known is in Kalamazoo Co., reported by C. R. Hanes, of Schoolcraft. Low mucky shore of Little Bostwick Lake, Kent Co., no. 1298, June 24, 1940.
- CAREX RUGOSPERMA* Mack. — Dune fields and oak clearings. Along M-16 at Nunica, Ottawa Co., no. 3260, July 7, 1940; cutover land near Spring Lake, Kent Co., no. 4871, July 21, 1942.
- CAREX SARTWELLII* Dewey. — A single station. Dean Lake, five miles northeast of Grand Rapids, Kent Co., no. 827, May 29, 1940.
- CAREX SICCATA* Dewey. — Three new stations: dry sterile hillside, Plainfield Township, Section 27, Kent Co., no. 3015, June 20, 1941; bluffs at Richard's farm, Ada Township, Kent Co., no. 2835, June 20, 1941; sand on north side of Penoyer Pond, Newaygo Co., no. 6459, May 25, 1945.
- CAREX SUBERECTA* (Olney)\* Britton. — Found in sedges sent to Dr. F. J. Hermann from the E. J. Cole herbarium. Tobey Lake, Caledonia Township, Section 23, Kent Co.
- CAREX SWANII* (Fern.) Mack. — Dense low woods, dune woods, and shaded ravines. Woods on Sand Creek south of M-50, Georgetown Township, Ottawa Co., no. 1556, July 10, 1940; low woods on Little Pigeon Creek, Ottawa Co., no. 1393, June 10, 1940; low woods on north side of Pigeon Lake, Ottawa Co., no. 1450, July 2, 1940; dense woods at Wabasis Lake, Kent Co., no. 1485a, July 4, 1940; Dorr, Allegan Co., no. 4588, June 22, 1942; Dumont Lake, Allegan Co., no. 4644, June 27, 1942.
- CAREX TRICHOCARPA* Muhl. — Crooked Lake, Kent Co., June 6, 1939, Sister M. Marcelline Horton. Only western Michigan record.
- CAREX TONSA* (Fern.) Bickn. — Common on sandy wastes, in dunes, and on sandy bluffs. Scott Creek bluffs, Kent Co., no. 1004, May 10, 1940; Grand Rapids Township, Section 2, no. 2886, May 30, 1940; Plainfield Township, Section 16, no. 1256, June 17, 1940; Mona Lake, Muskegon Co., no. 3759, Sept. 10, 1941; Muskegon City, Muskegon Co., no. 4515, May 23, 1942; dune meadow near Montague, Muskegon Co., no. 5062, Aug. 1, 1942; base of dunes on Lake Michigan at Stony Lake, Oceana Co., no. 4765, July 4, 1942; clearings at Brush Lake, Wilcox Town-

ship, Newaygo Co., no. 5380, June 24, 1943; sandy field, Kaleva, Manistee Co., no. 6435, May 1, 1945.

*CYPERUS DIANDRUS* Torr. — Rare. Sandy shores and in wet sand. Wet sand along Grand River at Lowell, Kent Co., no. 4211, Sept. 2, 1941; wet sandy shore, Omen Lake, Kent Co., no. 1747, July 20, 1940; shore of Stearn's Bayou, Ottawa Co., no. 1843, Aug. 1, 1940; wet sand along M-16 at Nunica, Ottawa Co., no. 5076a, July 19, 1942; dry lake bed, Little Blue Lake, Muskegon Co., no. 6761, Sept. 9, 1945.

*CYPERUS FERRUGINESCENS* Bueckl. — Sandy shore of Stearn's Bayou, Ottawa Co., no. 1849, Aug. 1, 1940; sandy shore, Pigeon Lake, Port Sheldon, Ottawa Co., no. 1800, Aug. 1, 1940; Wolf Lake, Muskegon Co., no. 4277, Oct. 5, 1941; in mud along Grand River at Lowell, Kent Co., no. 4251, Sept. 28, 1941.

*CYPERUS HOUGHTONII* Torr. — Very rare, a single record, Houseman and Fountain streets, Grand Rapids, Kent Co., no. 535, July 12, 1939.

*ELEOCHARIS COMPRESSA* var. *ATRATA* Svenson. — Wet sandy shores. Bostwick Lake, Kent Co., no. 1304, June 28, 1940; Silver Lake, Kent Co., no. 1409, July 5, 1940; Fruitport, Muskegon Co., no. 3384, July 7, 1940; roadside ditch, Pigeon Lake, Port Sheldon, Ottawa Co., no. 1440, July 2, 1940; shore of Pigeon Lake, Port Sheldon, Ottawa Co., no. 1610, July 20, 1940; beach of Lake Michigan, Cecil Bay, Emmet Co., no. 3845, Aug. 14, 1941; Hamlin Lake, near Baldwin, Lake Co., no. 3647, Aug. 3, 1941; Long Lake, Newaygo Co., no. 3716, Aug. 8, 1941; Beaver Island, Emmet Co., Sister M. Marcelline Horton.

*ELEOCHARIS ELLIPTICA* Kunth. — Marshy shore of Morgan Lake, Kent Co., no. 1221, June 19, 1940; sandy shore of Sandy Bottom Lake, Kent Co., no. 3346, July 11, 1941; interdunal marsh, Castle Park, Allegan Co., no. 5022, Aug. 4, 1941.

*ELEOCHARIS MELANOCARPA* Torr. — Although considered very rare when first discovered, four additional stations are now known in Kent Co. and one in Allegan Co.: sand on the edge of a pond one mile east of Knapp Avenue, Grand Rapids Township, Section 2, Kent Co., nos. 1528, 1583, July 8, 1940; shore of Pine Lake, Nelson Township, Section 35, Kent Co., nos. 1698, 1715, July 18, 1940; Allen Road and Clyde Park Blvd., Wyoming Township, Kent Co., no. 4597, June 23, 1942; at edge of a small swale,

one-half mile west of Knapp Avenue, Grand Rapids Township, Section 12, Kent Co., no. 6053, July 20, 1944; Ely Lake, Clyde Township, Allegan Co., no. 1156, June 6, 1940.

*ELEOCHARIS ROBBINSII* Oakes. — Very rare in Michigan; previously reported by C. R. Hanes, West Lake, Kalamazoo Co. I examined a specimen collected by P. E. Hebert, University of Notre Dame, at Buchanan Lake, Berrien Co. My only station is a marsh near Crawford Lake, Kent Co., no. 3333, July 11, 1941.

*ELEOCHARIS TRICOSTATA* Torr. — Woodland swale, two miles east of Fruitport along M-16 on south side of highway, no. 3032, Aug. 7, 1941; Ottawa Co., no. 5027, Aug. 11, 1942. A most unusual find. Dr. Henry K. Svenson, Brooklyn Botanical Garden, writes that it is the first station west of the Atlantic coast.

*RYNCHOSPORA macrostachys* Torr. — Very rare in Michigan, although previously reported in southwestern Michigan. C. R. Hanes, Niles Swamp, Kalamazoo Co., 1933, P. E. Hebert, and Bankson Lake, 1914, Dr. J. A. Nieuwland, formerly of Notre Dame University. New stations are Round Lake, Allegan Co., no. 4984, Aug. 4, 1942; one mile east of Knapp Avenue on M-114, Grand Rapids Township, Section 2, Kent Co., no. 4007, Aug. 28, 1942; McEwan Lake, Kent Co., no. 4187, Sept. 9, 1942; Bass Lake, Newaygo Co., no. 3637, Aug. 3, 1942; Little Blue Lake, Muskegon Co., no. 6736, Sept. 9, 1945.

*SCIRPUS FLUVIATILIS* (Torr.) Gray. — Marshy area near Grand River, Grand Rapids sewage disposal plant, Grand Rapids, Kent Co., no. 1630, July 16, 1940.

*SCIRPUS PEDICILLATUS* Fern. — Along east belt line, south of Hall St., Grand Rapids, Kent Co., no. 5955, Sept. 14, 1943.

*JUNCUS ALPINUS* Vill. var. *RARIFLORUS* Hartin. — Sandy shore, Sandy Bottom Lake, Kent Co., no. 3311, July 11, 1941; Long Lake, Newaygo Co., no. 385, Aug. 4, 1941; Duck Lake, Muskegon Co., no. 3185, July 7, 1941.

*JUNCUS BALTICUS* var. *LITTORALIS* f. *DISSITIFLORUS* Engelm. — Occasional along shore of Lake Michigan. Pigeon Lake, Port Sheldon, Ottawa Co., no. 2301, July 2, 1940; Bear Lake, Muskegon Co., no. 3207, July 7, 1941; Stony Lake, Oceana Co., no. 4703, July 4, 1942.

*JUNCUS BIFLORUS* Ell. — Very rare. Wet sandy fields on Boston Avenue, Grand Rapids, Kent Co., no. 2009, Aug. 21, 1940,

and no. 6547, Aug. 10, 1945; shore of Round Lake, Allegan Co., no. 4491, Aug. 4, 1942.

*JUNCUS PELOCARPUS* f. *SUBMERSUS* Fassett. — Shallow water on west shore of Crystal Lake, Newaygo Co., no. 3898, Aug. 17, 1941.

*JUNCUS EFFUSUS* var. *DECIPIENS* Buch. — Wet sand on east shore, Robinson Lake, Newaygo Co., no. 3742, Aug. 8, 1941. Dr. F. J. Hermann reports this as the first station in the Lower Peninsula.

*JUNCUS GREENII* Oakes & Tuckerm. — Gravelly and sandy hill-sides; not common. Fallasburg Park, Kent Co., no. 3960, Aug. 17, 1941; wet sand of roadside near Mona Lake, Muskegon Co., no. 5066, Aug. 14, 1942.

*JUNCUS MACER* f. *ANTHELATUS* (Wieg.) Hermann. — Occasional in wet areas near lakes. Shore of Dean Lake, five miles northeast of Grand Rapids, Kent Co., no. 2183, Aug. 4, 1940; along banks of Little Pigeon Creek, Ottawa Co., no. 1602, July 12, 1940.

UNION HIGH SCHOOL  
GRAND RAPIDS, MICHIGAN





## STUDIES ON PILOBOLUS: *P. KLEINII* AND *P. LONGIPES*

ERNST A. BESSEY

AMONG the most interesting of the Mucorales are the species of *Pilobolus*, which occur in nature almost exclusively on the dung of various, mainly herbivorous, animals. Freshly voided horse droppings brought into the laboratory and placed in a covered glass dish on a table near a window will usually show a great number of the sporangiophores of *Pilobolus* within a week or ten days, and the side and cover of the dish toward the light will be peppered with the almost black sporangia, which are shot off violently toward the region of greatest illumination. In the sixth volume of his *Researches on Fungi* the late A. H. Reginald Buller (1934) devoted over two hundred pages to these fungi; their habits, structure, relation to light, and in particular the mechanism and physiology of the discharge of the sporangia. In the same work W. B. Grove discussed their taxonomy.

According to Grove (1934), the first published description of these fungi was by John Ray, the British botanist, in 1688. The first mention of the discharge of the sporangia appears to be that of Tode (1784), in which he called the fungus "Hutwerfer" and gave to it the generic name *Pilobolus*, the Greek equivalent of the German name. Gradually the number of species recognized grew until in 1934 Grove listed sixteen, seven of these being somewhat uncertain, in his opinion. Palla (1900) indicated that some of the so-called species are perhaps better regarded as groups of closely related species. This is his opinion particularly of the species groups *crystallinus*, *kleinii*, and *sphaerosporus*. Until the various forms of these groups have been grown under identical conditions in pure cultures, in synthetic culture media or at least in the same lot of culture media, it will be impossible to say with certainty whether they are groups of closely related microspecies or merely ecological forms dependent upon the culture medium and other external factors.

In this paper the two species discussed fall beyond doubt into the two species groups *Pilobolus kleinii* van Tieghem and *P. longipes* van Tieghem. According to Buller, these are the commonest species in Manitoba, whereas Grove and Palla consider *P. kleinii* and its kindred microspecies to be the commonest species in the world. The strains studied by the writer were obtained from freshly dropped horse dung from the horse barns of Michigan State College, East Lansing.

The species of *Pilobolus* were shown by Egon Bersa (1930) to depend chiefly upon xylan, one of the pentoses, for their carbon source, and upon such substances as peptone, albumen, asparagin, and, best of all, leucine, as the sources of their nitrogen. The undigested pentoses, chiefly xylan, as well as various nitrogenous substances, are present in the dung.

In my experiments the best culture medium, aside from manure, was a water extract of horse manure, strained through cotton to remove the larger particles, to which were added 2 per cent by weight of powdered agar and an equal amount of ground rolled oats, the whole being autoclaved at least an hour at a pressure of 12 to 15 lbs. to kill the numerous spore-producing bacteria present. Manure-extract agar without the rolled oats but with glucose added proved unsuitable for cultivating these fungi.

The vegetative mycelium is submerged in the culture medium, never producing an aerial growth. It is fine, much-branched, tapering, with somewhat granular contents. Like most Mucorales, it is nonseptate, except where a wall is formed to fence off a portion in which the contents have become exhausted. From this actively growing mycelium arise thicker, usually yellowish, unbranched hyphae which seek the surface and emerge as stout, bluntly pointed cylinders whose tips are phototropic, so that they turn toward the source of light. This usually occurs during one day. During the night the basal submerged or superficial portion of this sporangio-phore enlarges, becoming separated by a septum into a basal swelling (Pl. I, Fig. 1A), usually having the shape of a turnip or beet, which tapers into a rather straight hypha connecting with the mycelium, and a bulb-shaped or cylindrical trophocyst (Pl. I, Fig. 1B), from whose apex arises directly or at an angle of 45° to 90° the sporangio-phore proper (Pl. I, Fig. 1C). The tip of this swells to form the sporangium (Pl. I, Fig. 1F), which is soon cut off by a septum. The

sporangium is filled with a yellow or an orange protoplasm, and the wall at first is colorless and transparent. By early morning the top and side walls have taken on their normal blue-black or black color, and just below the sporangium the apical portion of the sporangiophore enlarges to form the oval or pyriform subsporangial vesicle (Pl. I, Fig. 1 D). The upper end of this vesicle is extended into a more or less conical, usually blunt, columella (Pl. I, Fig. 2), which presses into the lower side of the sporangium, sometimes nearly reaching the upper wall at the center. The spores are numerous and embedded in a gummy substance. They are angular by mutual pressure until they escape from the sporangium and become separated by the dissolving of the gum. At maturity, usually by late forenoon, the sporangium wall dehisces circumscissilely where it comes in contact with the vesicle, probably because of the pressure from the gum surrounding the spores. This gummy mass projects around the opening (Pl. I, Fig. 1 E).

Very shortly after this stage is reached the increased osmotic pressure in the vesicle, sporangiophore, and trophocyst tears the columella from the surrounding circular liplike structure, and the columella, sporangium, and contained spores are shot off, violently propelled by the escaping stream of liquid from the opening at the top of the vesicle. Buller measured the height to which the sporangia might be projected when the illumination was directly from above and showed that for the two species under consideration it occasionally reached six feet, whereas with lateral illumination the sporangia could be thrown eight feet. The top of the sporangium is dry and nonwetable, and does not adhere to objects but rolls over, so that the under side of the columella, wet by the liquid expelled from the vesicle, sticks fast to the object which it may reach. There it dries, and if it be a blade of grass, it is carried into the stomach of an animal eating the leaf. In the alimentary canal the gummy substance in which the spores are embedded dissolves, and the spores are distributed throughout the feces. After these have been set free from the body of the animal, the spores germinate, and if moisture and temperature are favorable, new mature sporangia are shot off within five or six days. Passage through the alimentary canal of an animal is not necessary, however, for the germination of the spores, since these fungi may be grown in culture indefinitely by inoculation with sporangia directly into suitable culture media.

A culture that has begun to produce sporangia may continue to do this for many weeks if not allowed to dry out too much.

The characters upon which specific distinctions are made in the genus *Pilobolus* are the following:

Color of the sporangium: Bluish black to black in all species except *P. nanus*, in which the mature sporangia are yellow.

Color of spores: Orange in some, pale yellow or colorless in others.

Thickness of spore wall: In *P. longipes* and *P. oedipus* there are a sharply distinct inner wall and a colorless outer wall about 0.8 micron thick.

Shape of spore: Spherical or nearly so as contrasted with decidedly ellipsoidal.

Size of spores: In some they are large and in others small, while in one species spores of all sizes occur in the same sporangium.

Ease of separation of spores from gummy mass containing them.

The shape and size of the trophocyst, of the vesicle, and of the sporangium are also important characters, but these vary much with the medium and with external conditions, as does the total size of the structure.

The chief points of distinction between *P. kleinii* and *P. longipes* (based solely upon the East Lansing strains) are given in Table I.

In general, *Pilobolus longipes* is a larger species than *P. kleinii*. The sporangia average slightly broader, and the surface is finely and shortly aculeate in the former and roughened, rarely aculeate, in the latter. The subsporangial vesicle is oval and a little larger in the former and pyriform in the latter. The trophocysts are the most conspicuous points of difference. In *P. longipes* they are cylindrical or lanceolate in outline, averaging about four times as long as the greatest width, and are more or less horizontal, often superficial when grown on manure but usually submerged in agar cultures. In *P. kleinii* they are shaped like an inverted turnip or are bulblike, being more often upright, about three fourths as wide as tall. They rarely project above the surface of the medium. In both species the basal swellings are quite similar, but are usually a little longer in *P. longipes*. The columella is much smaller and lower in *P. kleinii*.

The spores are subspherical or spherical in *P. longipes* and distinctly ellipsoidal in *P. kleinii*, with a tendency to be broader in the

TABLE I

CHIEF DIFFERENCES BETWEEN *P. KLEINII* AND *P. LONGIPES*

	<i>P. kleinii</i>	<i>P. longipes</i>
Sporangium...	Surface finely roughened, rarely aculeate. 45-900 $\mu$ broad; average of 393 sporangia 233 $\mu$ . Pl. I, Fig. 1 F	Surface finely aculeate. 78-720 $\mu$ broad; average of 115 sporangia 248 $\mu$ . Pl. II, Fig. 1 E
Vesicle .....	Pyriform. 375-945 $\mu$ long by 225-705 $\mu$ broad (av. 573 $\times$ 384). Ratio of breadth to length 0.67. Pl. I, Fig. 1 D	Oval. 345-1,050 $\mu$ long by 225-750 $\mu$ broad (av. 684 $\times$ 512). Ratio of breadth to length 0.75. Pl. I, Fig. 3; Pl. II, Fig. 1 D
Trophocyst ...	Having shape of inverted turnip; usually upright and submerged in the medium. 105-520 $\mu$ tall (av. 353), 165-315 $\mu$ wide (av. 278), constricted at basal septum. Pl. I, Fig. 1 B	Cylindrical or lanceolate in outline, horizontal or inclined 45 $\mu$ , broadest between middle and basal septum, where it is constricted. 300-1,350 $\mu$ long (av. 880), 120-315 $\mu$ broad (av. 217). Pl. II, Figs. 1 B, 2
Basal swelling	Turnip-shaped; hyaline when sporangia are mature. 60-155 $\mu$ broad, tapering to a nearly uniform stout hypha at distance of 125-375 $\mu$ . Pl. I, Fig. 1 A	Turnip-shaped; yellow when sporangia are mature. 105-180 $\mu$ broad, tapering to stout hypha at distance of 150-570 $\mu$ . Pl. II, Fig. 1 A
Columella ....	40-50 $\mu$ high and as wide, or only a little wider, at base; bluntly conical. Pl. I, Fig. 2	53-210 $\mu$ high, 105-300 $\mu$ wide at base; obtuse at top, upper part almost cylindrical or even slightly narrowed at middle; rarely low-conical. Pl. I, Figs. 3-4
Sporangiophore	420-3,450 $\mu$ tall (av. 1,477), 67-120 $\mu$ broad near vesicle, 57-105 $\mu$ broad near base. Pl. I, Fig. 1 C	1,725-8,250 $\mu$ tall (av. 4,463), 75-210 $\mu$ broad near vesicle, 60-150 $\mu$ broad near base. Pl. II, Fig. 1 C
Total height ..	3.75-5 mm. (av. 4.4 mm.)	2.0-8.0 mm. (av. 5.2)
Spores .....	Ellipsoidal, orange, thin-walled. 7.9-20.9 $\mu$ by 7.0-13.7 $\mu$ . Average in larger sporangia (above 570 $\mu$ ), 13.2 $\times$ 11.4 $\mu$ , in sporangia 550 $\mu$ and smaller, 13.2 $\times$ 8.6 $\mu$ , yet in one sporangium 600 $\mu$ broad averaging 12.2 $\times$ 7.5 $\mu$ . Pl. II, Fig. 4	Subspherical to spherical, orange yellow, wall double, a distinct thin inner wall and a transparent outer wall 0.8 $\mu$ thick. 7.4-16.8 $\times$ 7.2-14.9 $\mu$ (av. 13.5 $\times$ 12-15). Pl. II, Fig. 3

larger sporangia of the latter than in the smaller ones. There is a marked difference in the spore walls; in *P. kleinii* they show only one distinct layer. In *P. longipes*, on the other hand, besides the distinct inner wall there is a transparent outer wall about  $0.8 \mu$  thick. It is possible that the latter is soluble, for in sporangia that have stood many hours or a few days in droplets of condensation water on the side of the flask in which the culture was growing one finds difficulty in distinguishing it. In color there are some differences. In the mature sporangiophore the basal swelling of *P. longipes*, below the trophocyst, is packed with very small granules, so that in transmitted light it looks dark but in reflected light appears orange yellow. In *P. kleinii* at this stage it is practically empty. The protoplasmic collar at the lower end of the subsporangial vesicle is large in the latter species and sometimes almost closes the opening to the sporangiophore. It is orange-colored. It is much less evident in *P. longipes*. In both species shortly before the sporangium is mature the orange granules of the vesicle may form a beautiful network over the whole inner surface of the wall, but at maturity the vesicle is practically clear. The wall of the vesicle, sporangiophore, and trophocyst of *P. longipes* at full maturity has a pale yellow tinge which is lacking in *P. kleinii*.

A striking difference is shown when the two species are treated with chloriodide of zinc solution. In my *P. kleinii* no part of the fruiting structure or of the vegetative mycelium takes on a violet or purplish coloration except a very narrow ring at the opening of the vesicle, where the abscission of the columella has left a slightly thickened lip. In my *P. longipes* this lip is much more heavily colored by the reagent and, in addition, the lower two thirds or three quarters of the wall of the sporangiophore, and the walls of the trophocyst, the basal swelling, and even of the vegetative mycelium are stained a purple brown or violet brown. Apparently the chitin content of the walls is not sufficient in this species, except in the upper portion of the sporangiophore, to prevent the color reaction by the cellulose or cellulose-related substance composing a large part of the wall. It would be interesting to determine whether the same condition is true for the large forms of *P. longipes*, whose fruiting bodies are sometimes ten times as tall and are much thicker than those in the form I had. Possibly other species from various regions may vary in their reaction. Klein (1872) observed the staining of the cell wall of *Pilobolus* on

treatment with iodine dissolved in KI solution. He reported the wine-red coloration of the cell wall of the whole sporangiophore and trophocyst, basal swelling, and vegetative mycelium in some tests or only of the lower portion of the sporangiophore in others. Probably he was dealing with different species. He did not have pure cultures of his fungi, for in some of his fungi he had round and in others ellipsoidal spores, and the latter were orange-colored and large or almost hyaline and small. He was inclined to the belief that all were perhaps merely forms or different stages of development of the same species. Unfortunately he did not indicate upon which of these forms he made his tests with iodine solution. He apparently had at various times *P. crystallinus* (Weber) Tode, *P. roridus* (Bolt.) Pers., *P. kleinii* van Tieghem, and *P. sphaerosporus* Palla.

Although on the average the spores of *P. kleinii* are broader in proportion to their length in the larger sporangia, it is interesting to note that in a culture from a single sporangium the sizes of the sporangia produced are extremely variable. A number of such cultures were made, being inoculated with single sporangia of different sizes for each culture. The results are shown in Table II.

TABLE II

RELATION OF SIZE OF SPORANGIUM USED AS INOCULUM TO SIZE OF THE SPORANGIA PRODUCED IN THE CULTURES (*P. KLEINII*)

Diameter of sporangium used as inoculum	Range of size in the sporangia produced	Average size of spo- rangia produced
(a) 120 $\mu$	90-360 $\mu$	213 $\mu$
(b) 150 $\mu$	82-315 $\mu$	166 $\mu$
(c) 180 $\mu$	60-450 $\mu$	225 $\mu$
(d) 338 $\mu$	60-420 $\mu$	195 $\mu$
(e) 345 $\mu$	60-405 $\mu$	146 $\mu$
Av. 231 $\mu$	...	180 $\mu$ (204 sporangia)

Transfers of sporangia of (a), (c), (d), and (e) into soyka dishes containing autoclaved horse manure gave sporangia of various sizes as follows: (a) 60-308  $\mu$ , av. 192  $\mu$ ; (c) 99-420  $\mu$ , av. 259  $\mu$ ; (d) 97-420  $\mu$ , av. 240  $\mu$ ; (e) 45-430  $\mu$ , av. 215  $\mu$ .

From the foregoing data it is apparent that for *P. kleinii* the size of sporangium used as inoculum has no close correlation with the size of the sporangia produced by the resulting cultures.

In *P. longipes* also the sporangium size of the culture varied greatly



from the size of the sporangium used as inoculum. Thus in one culture the sporangia produced ranged from 187 to 615  $\mu$ , with an average of 373  $\mu$ .

In a culture of *P. kleinii* in manure extract and ground rolled oats and agar an abundant production of sporangia occurred for several weeks. There was early a small bacterial colony which grew until the agar was pretty well covered. The culture was examined about three months after it was started. There were no zygospores. The lateral branches of the vegetative mycelium, instead of tapering to points, were swollen terminally and produced terminal and intercalary chlamydospores with a pale brown wall about 2  $\mu$  thick. Sometimes clusters of these chlamydospores resembling bunches of grapes occurred near the trophocysts, arising from the same hyphae. Possibly exhaustion of the medium or toxic action of the bacteria was responsible for the production of the chlamydospores.

Sexual reproduction has rarely been observed in *Pilobolus*. In 1888 Zopf described and illustrated zygospore formation (Pl. III, Figs. 2-5) in *P. kleinii* (which he erroneously identified as *P. crystallinus*). He found this only where the fungus was parasitized by *Pleotrachelus fulgens* Zopf or by *Syncephalis* sp. In his illustrations he shows several zygospores in various stages of development, one of them with the two suspensors arising from the same hypha. He mentions this occurrence particularly in his text (Pl. III, Fig. 2, of the present paper). This would mean that the species is homothallic. According to Blakeslee (1904), Dr. Roland Thaxter observed these zygospores but did not publish on them. In 1906 Morini described and figured zygospores in *P. borzianus* Morini, but did not give any clue whether the species is homothallic or heterothallic. In 1931 Hans Krafczyk reported zygospore formation (Pl. III, Fig. 6) in agar cultures of *P. crystallinus* (Weber) Tode. These were produced only when two strains of opposite sex were mated. The species is definitely heterothallic.

I was fortunate enough to obtain one lot of fresh horse manure upon which sporangiophores of *P. kleinii* arose in great abundance, with no signs of attack by *Pleotrachelus* or by *Syncephalis*. In the upper two or three millimeters of the manure large numbers of the zygospores were produced. In another lot of manure two months later a few sporangiophores were produced, and several trophocysts and other organs were infected by *Pleotrachelus fulgens* (Pl. III,

Figs. 8-9). In this culture, too, a large number of zygospores appeared. In the suspensors and supporting hyphae of a few of these were numerous spherical to ellipsoidal sporangia of an *Olpidium*-like fungus, 7-10  $\mu$  in longer dimension (Pl. III, Fig. 7). Some perforated the *Pilobolus* wall by a single short exit tube, but since no zoospores could be observed the identity of the fungus could not be determined. In some of the sporangia instead of thin walls the walls were about 0.7  $\mu$  thick. The contents of the sporangia, both thin- and thick-walled, were yellowish but the walls were hyaline.

In none of the cultures made in agar combinations were zygospores produced, whether inoculation was made by a single sporangium or by many sporangia or by mating cultures originated from sporangia of different sizes and origin, or even by attempting to cross *P. kleinii* and *P. longipes*. In none of the manure cultures or agar cultures of the latter species could I find zygospores.

The zygospores (Pl. III, Fig. 1) of *P. kleinii* are more or less spherical, sometimes longer in the vertical direction, sometimes flattened, so that the equatorial direction is the greater. The measurements of thirty-four mature or fully grown zygospores ranged from 53 to 150  $\mu$  in both directions, the average dimension being 97 and 88  $\mu$  for height and equatorial diameter respectively. When the zygospores are immature, the outer wall is smooth and almost colorless, and the interior of the zygospore contains many small or a few large yellow drops. At zygospore maturity the outer wall, the original wall of the united gametangia, is ruptured and forms flakes of various sizes which give the zygospore a roughened appearance. The interior wall of the mature zygospore is 2 to 4.4  $\mu$  thick and is pale brown, as are the walls of the pyriform suspensors. In the mature spore the oil drops have disappeared, and the contents are finely granular.

The suspensors are caught around one another at the slender bases and at the contact surfaces various finger-like lobes and branches wind around the supporting hyphae, sometimes interlocking like the fingers of clasped hands. In my opinion this structure serves to hold the suspensors tight at the bottom. At first they are relatively slender and parallel, but later bow out until the tips meet at an obtuse angle, the bodies of the suspensors rapidly becoming thicker. The gametangia are then cut off near the tips by cross septa, and soon the flattened mutual wall between the greatly enlarged cells dissolves

out and the zygosporangium is produced. At the beginning the latter is enclosed only in the walls of the gametangia but immediately an inner wall begins to be deposited. In the meantime the suspensors have become pyriform and have resumed contact with each other for their full length. No two zygosporangia were found in which the entanglements at the bases of the suspensors were alike. As shown in some of Zopf's illustrations, this entanglement may be scarcely more than a simple twining once of the two hyphae or a very complicated system of interlocking fingers may be developed.

In the specimens examined there was no evidence to indicate whether *P. kleinii* is heterothallic or homothallic. The cultures in sterile manure and in manure-extract agar did not produce any zygosporangia, whether the inoculum was one sporangium or a large number of sporangia.

Several attempts were made to obtain cultures by inoculating a zygosporangium of *P. kleinii* into sterilized manure and into agar made up with extract of manure with various additions. Other fungi as well as bacteria, evidently contaminants on the surface of the zygosporangium, grew, but no trace of *Pilobolus* appeared in over two months, by which time the cultures had become too dry for growth of this fungus.

MICHIGAN STATE COLLEGE  
EAST LANSING, MICHIGAN

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**PLATES I-III**

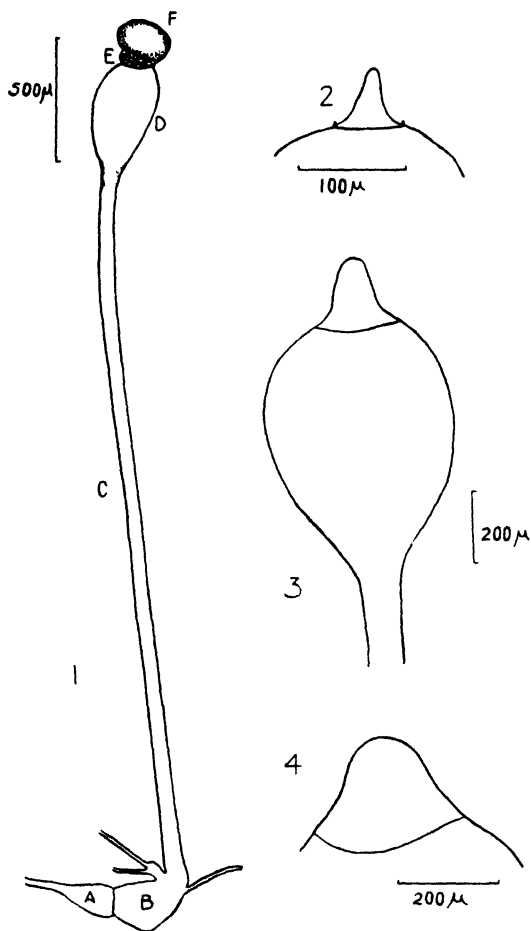


FIG. 1. *Pilobolus kleinii* van Tieghem: A, basal swelling; B, trophocyst; C, sporangiophore; D, subsporangial vesicle; E, mass of spores embedded in gum at base of partially opened sporangium; F, sporangium

FIG. 2. *P. kleinii*, columella and upper portion of subsporangial vesicle

FIG. 3. *P. longipes* van Tieghem, subsporangial vesicle and more typical form of columella

FIG. 4. *P. longipes*, broader, less typical, form of columella



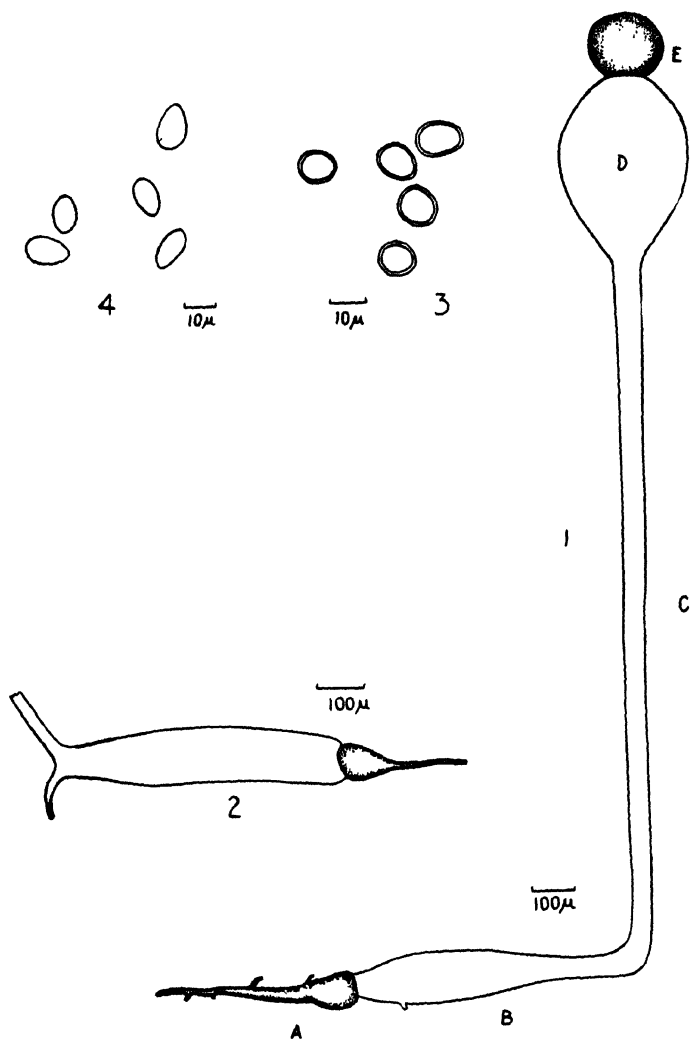


FIG. 1. *P. longipes*; A, basal swelling; B, trophocyst; C, sporangiophore; D, subsporangial vesicle; E, sporangium

FIG. 2. *P. longipes*, another trophocyst and basal swelling

FIG. 3. *P. longipes*, spores showing thick walls and spherical shape

FIG. 4. *P. kleinii*, spores showing thin walls and ellipsoidal shape





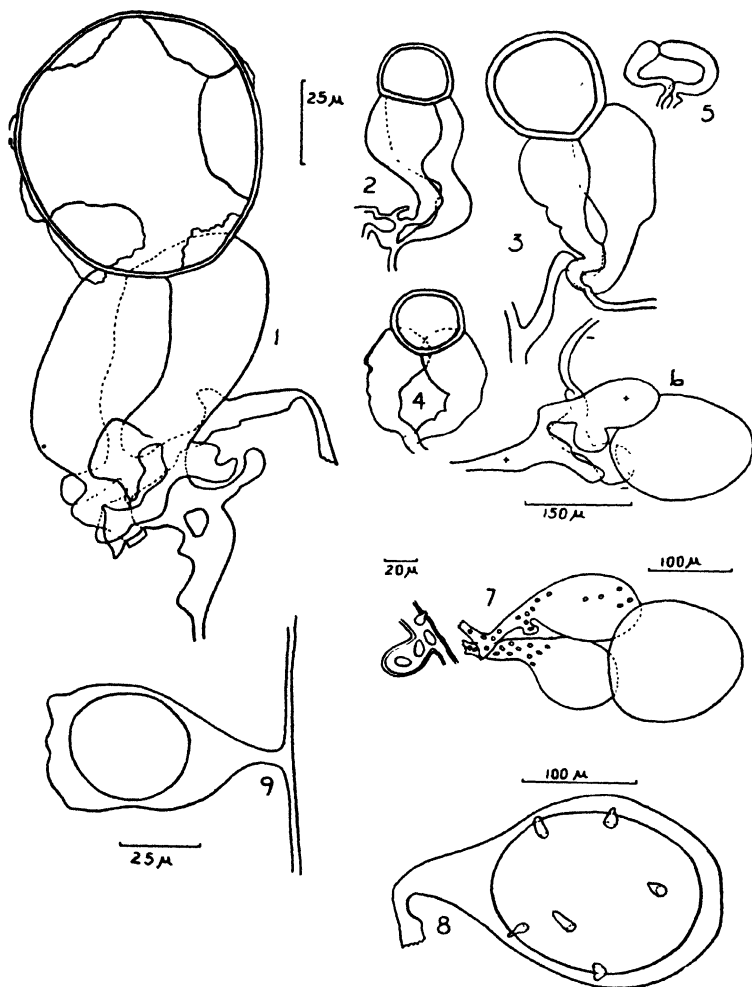


FIG. 1. *P. kleinii*, zygospore

FIGS. 2-5. *P. kleinii*, after Zopf. In Figure 2 the homothallic origin of the zygospore is shown

FIG. 6. Zygospore of *P. crystallinus* Tode, after Krafczyk

FIG. 7. Zygospore of *P. kleinii* showing zoosporangia of an Olpidium-like fungus in the suspensors and supporting hyphae

FIG. 8. *Pleotrichus fulgens* Zopf in trophocyst of *P. kleinii*

FIG. 9. Young zoosporangium (?) of *Pl. fulgens* in a heaped-up mass of the protoplasm in a sporangiophore of *P. kleinii*



# ADDITIONS TO AN ANNOTATED LIST OF THE HIGHER PLANTS OF THE REGION OF DOUGLAS LAKE, MICHIGAN. III \*

FRANK C. GATES

*Kansas State College*

AND

JOHN H. EHLERS

*University of Michigan*

IN 1909 the University of Michigan established the Biological Station at Douglas Lake, Cheboygan County, Michigan. As stated in the first paper in this series, in the same year F. M. Loew began to list the plants in the vicinity of the station in Cheboygan and Emmet counties, the two northernmost counties of the Lower Peninsula. In 1911 F. C. Gates, who was then serving as an agent of the Michigan Biological and Geological Survey, brought the number of species up to 530. This list was published in the *Fourteenth Report of the Michigan Academy of Science* (1912), pp. 46-106.

Upon the return of F. C. Gates to the station in 1915 and the coming of J. H. Ehlers in 1916 a program for the active study of the higher plants of the region was instituted. In 1925 they published in the *Papers* an annotated list of the plants, and in 1928 and 1931 made additions to it.<sup>1</sup>

It was the original intention of the authors to publish additions every five years, but circumstances, including the retirement of Dr. Ehlers in 1938, prevented the carrying out of the plan. Fortunately, it is now possible to present a third list of additions, which increases the number of species and varieties to 1,226. This list, covering the first thirty years of systematic botanical work in the two counties mentioned, brings to a close our joint reports on the flora of the Douglas Lake region.

\* Contribution 472 from the Department of Botany of Kansas State College and Paper 840 from the Department of Botany of the University of Michigan.

<sup>1</sup> *Papers* 4 (1924): 183-284. 1925; 8 (1927): 111-120. 1928; 13 (1930): 67-88. 1931.

The period of our botanical investigations has witnessed great changes in the activities of this region. At the beginning there was a thriving lumber industry, but at present little wood other than that used for fuel or for poles is being cut. Great areas of cut-over land, good, medium, and bad, that were once devoted to farming are now abandoned, and, where cultivation was thorough, are growing up in grass. In other places forests of aspen, beech-maple, pine, or white cedar are intruding upon them. Instead of numerous small streams one now finds ditches and drainage canals, many of which are dry most of the time. The winding sand roads through the woods have been replaced by macadam or gravel roads, although there are a few black-top ones. Horse-drawn vehicles have yielded to automobiles. Originally no fruits were cultivated, but there is now some sporadic raising of small fruits such as raspberries and strawberries, and a few apple orchards. The amount of fruit picked from wild areas still exceeds that grown under cultivation; it consists mostly of blueberries and blackberries, and small quantities of cranberries. All of the towns have diminished in size. There has been some increase in the number of recreational camps, as well as in tourists' accommodations during the summer and in hunting facilities during the late fall. Many trees have been planted on University properties and a few elsewhere. Forest fires, the former bane of the region, have virtually been eliminated.

An interesting case history of the difficulties of the city of Cheboygan between 1890 and 1940, written by D. L. Gibson, entitled *Socio-Economic Evolution in a Timbered Area in Northern Michigan*, was published in 1944 by the Michigan Agricultural Experiment Station as Technical Bulletin No. 193.

Our data are now grouped under five headings instead of the customary four. They are as follows: (1) new records for the region; (2) new records for Emmet County; (3) new records for Cheboygan County; (4) verifications of Emmet County records by C. W. Fallas and C. H. Swift; and (5) new records made by the senior author, 1938-45. The families are arranged as in the other papers of the series and numbered accordingly.

In a study of the grasses of the Douglas Lake region L. H. Harvey published in the *Papers*, 25 (1939): 43-46. 1940, with permission, a number of records which would otherwise now be given for the first time. His name is added to each repeated record.

In this list the letters "E." and "C." at the extreme right indicate Emmet and Cheboygan counties.

NEW RECORDS FOR THE REGION

In this section are included plants found in the region for the first time since the publication of the original list and its two additions and also species for which identifications have since been made.

**Phylum LEPIDOPHYTA**

1. LYCOPODIACEAE (Club Moss Family)

- LYCOPODIUM INUNDATUM L. C.  
Sandy shore of Vincent Lake, 1933; bog mat at Little Lake Sixteen, 1936; spreading rapidly.

**Phylum ANTHOPHYTA**

2. BUTOMACEAE

- BUTOMUS UMBELLATUS L. E.  
Near Alanson, by V. J. Wulff, 1938, July.

6. SPARGANIACEAE (Burreed Family)

- SPARGANIUM ANDROCLADUM (Engelm.) Morong (*S. americanum androcladum* (Engelm.) Fernald & Ames) E.  
In Crooked River at Alanson, 1934.

9. POTAMOGETONACEAE (Pondweed Family)

- POTAMOGETON ANGUSTIFOLIUS Berchtold & Presl C.  
Maple Bay, Douglas Lake, 1933; Black Lake outlet, 1934.  
POTAMOGETON EPIHYDRUS Raf. C.  
Lancaster Lake, 1933. Rare.  
POTAMOGETON HETEROPHYLLUS f. TERRESTRIS Schlecht. E.C.  
A common form in low-water years, but not previously mentioned by name.  
POTAMOGETON OBTUSIFOLIUS Mertens & Koch E.  
Shallow water of Carp Lake, 1933.  
POTAMOGETON ROBBINSII Oakes E.C.  
Crooked River at Alanson, 1935; Pigeon River near Mullet Lake, 1937. Rare.

POTAMOGETON STRICTIFOLIUS RUTILOIDES Fernald C.

A variety additional to the species from the outlet of Black Lake, 1932.

#### 10. LILIACEAE (Lily Family)

MAIANTHEMUM CANADENSE PUBESCENS E.C.

The pubescent form occurs with the glabrous form in various pineland areas in both counties.

#### 12. PONTEDERIACEAE (Pickerelweed Family)

HETERANTHERA DUBIA (Jacq.) MacM. E.C.

Black Lake near outlet, 1933; Crooked River near Alanson, 1938.

#### 16. XYRIDACEAE (Yelloweyed Grass Family)

XYRIS MONTANA Ries. C.

Mat at Little Lake Sixteen, 1936.

#### 18. JUNCACEAE (Rush Family)

JUNCUS ALPINUS RARIFLORUS Hartm. E.C.

This variety, determined by F. J. Hermann, was formerly listed as *Juncus alpinus insignis*. Frequent on wet gravelly and sandy shores.

JUNCUS EFFUSUS COMPACTUS Lejeune & Courtois E.

Swampy banks of Crooked River, 1938. (A variety added.)

JUNCUS MILITARIS Bigel. C.

Little Lake Sixteen, forming floating islands in the lake and later in the mat on the east side.

JUNCUS PELOCARPUS Mey. C.

Border of Penny Lake, 1932; sandy shore of Vincent Lake, 1935; mat of Little Lake Sixteen, 1936.

JUNCUS VASEYI Engelm. C.

Sandy flat, Penny Lake, 1933.

#### 30. CYPERACEAE (Sedge Family)

CAREX NORMALIS Mackenzie C.

Wooded shore of Burt Lake, 1930.

CAREX SETACEA AMBIGUA (Barratt) Fernald C.

Roadside ditch along road to Cheboygan, 1932.

ELEOCHARIS OBTUSA (Willd.) Schultes C.

Muddy banks of Nigger Creek, near Mullet Lake, 1938.

*SCLERIA VERTICILLATA* Muhl.

E.

Bog margin at Cecil Bay, 1938.

31. POACEAE (Grass Family)

*FESTUCA OCTOFLORA* Walt.

C.

Along a path at the Biological Station, probably brought in mud by automobiles. Ehlers, as recorded in L. H. Harvey, 1940.

*ERAGROSTIS POAEOIDES* Beauv.

C.

Ballast of Michigan Central Railroad, Mackinaw City, 1937, L. H. Harvey, in Harvey, 1940.

*PHRAGMITES COMMUNIS* f. *REPENS*

E.

With long runners (to 43 feet) on clayey-rocky flats of Lake Michigan east of Cecil Bay, 1937, L. H. Harvey, in Harvey, 1940.

*AGROPYRON SUBSECUNDUM* (Link) Hitchc. (*A. caninum* of our previous list)

C.

Sandy shore, Straits of Mackinac.

*LOLIUM TEMULENTUM* L.

C.

Cheboygan dumping ground, 1938, L. H. Harvey, in Harvey, 1940.

*AGROSTIS PALUSTRIS* Huds. (*A. maritima* Lam.) (This name was used for *Agrostis alba* L. in our previous list.)

C.

Cheboygan dumping ground, 1935. Ehlers, as recorded in Harvey, 1940.

*SPOROBOLUS CRYPTANDRUS* (Torr.) A. Gray

C.

Along U. S. Highway 23 near Mackinaw City, 1937, L. H. Harvey, in Harvey, 1940.

*BECKMANNIA SYZIGACHNE* (Steud.) Fernald

E.

Bordering a cold spring at Alanson, 1932. Ehlers, as recorded in Harvey, 1940. New also to Michigan (fide Harvey).

*PHALARIS CANARIENSIS* L.

C.

Cheboygan dumping ground, 1938, L. H. Harvey, in Harvey, 1940.

*PHALARIS ARUNDINACEA PICTA* L.

C.

Grassy banks of Cheboygan River at Cheboygan, 1934.

*PANICUM LINDHEIMERI* Nash.

C.

Marshy shore of Duncan Bay, 1938. (Determined by J. R. Swallen.)



## PANICUM MILIACEUM L.

C.

Cheboygan dumping ground, 1933.

## 35. IRIDACEAE (Iris Family)

## IRIS VIRGINICA L.

E.C.

Swamps at head of Burt Lake, 1931; Duncan Bay; Indian River; Cecil Bay.

## 45. ORCHIDACEAE (Orchid Family)

## CALYPSO BULBOSA (L.) Oakes

E.C.

Shaded banks of Duncan Bay, 1931, by R. L. Walp, under pines in Big Stone Bay, 1933.

## HABENARIA DILATATA MEDIA (Rydb.) Ames

E.

Margin of bog in Cecil Bay, 1933. (A variety of the species previously listed as *Limnorchis dilatata*.)

## 80. MORACEAE (Mulberry Family)

## CANNABIS SATIVA L.

C.

Weed in barnyard at Ingleside, 1924.

## 104. EUPHORBIACEAE (Spurge Family)

## GALARRHOEUS ESULA (L.) Rydb.

E.

Sandy soil, along U. S. Highway 31 south of Carp Lake, 1935.

## CHAMAESYCE HUMISTRATA (Engelm.) Small

E.

Waste ground in Mackinaw City and in Bayview, 1931.

## 108. HYPERICACEAE (St. John's Wort Family)

## HYPERICUM CANADENSE L.

E.

Marsh around French Farm Lake, 1930.

## 132. BRASSICACEAE (Mustard Family)

## ERUCASTRUM GALLICUM (Willd.) O. E. Schulz

C.

Cheboygan dumping ground, 1933.

## 140. SALICACEAE (Willow Family)

## SALIX CANDIDA × S. BEBBIANA

C.

In a Larix bog across the Cheboygan-Levering road north of Mud Lake, 1935.

146. CHENOPODIACEAE (Goosefoot Family)

- ATRIPLEX PATULA L. C.  
Cheboygan dumping ground, 1936. Varieties *hastata* (L.) Gray  
and *littoralis* (L.) Gray; both in the same place, 1933.

147. POLYGONACEAE (Smartweed Family)

- POLYGONUM DOUGLASII Greene E.  
Sandy shore of Lake Michigan near Cross Village, 1932.  
POLYGONUM STEVENSII Brenckle E.  
Beach at Cecil, Aug. 22, 1936 (F. C. G. 19582). (Determined by  
Brenckle in 1941.)

151. PRIMULACEAE (Primrose Family)

- LYSIMACHIA NUMMULARIA L. C.  
Low ground, and submerged in Mud Creek, inlet into Carp Lake,  
1935.  
STEIRONEMA QUADRIFLORUM (Sims) Hitchc. C.  
Grassy shore of Black Lake at Fairview, 1937.

169. BORAGINACEAE (Borage Family)

- ANCHUSA OFFICINALIS L. C.  
Abandoned house at Riggsville Corners, 1935.  
SYMPHYTUM OFFICINALE L. C.  
Waste ground, Cheboygan, 1934.

172. OLEACEAE (Olive Family)

- LIGUSTRUM VULGARE L. E.  
Shrub, escaping along Grand Rapids and Indiana Railroad (now  
Pennsylvania Lines) near Kegomic, 1930.

178. SCROPHULARIACEAE (Figwort Family)

- CASTILLEJA PALLIDA SEPTENTRIONALIS (Lindl.) Gray E.  
Bogs west of Cecil, 1936.  
VERBASCUM BLATTARIA ALBIFLORUM Ktze. E.  
Roadside west of Pellston, 1931. A variety (better, a form) of  
the species previously recorded.

## 182. OROBANCHACEAE (Broomrape Family)

ANOPLANTHUS UNIFLORUS (L.) Endl. (Orobanche, Aphyllon, Thalesia) C.

At margin of coniferous woods, east shore of Duncan Bay, 1931.

## 185. LENTIBULARIACEAE (Bladderwort Family)

UTRICULARIA CLANDESTINA Nutt. C.

Livingston Bog, 1932, by G. E. Nichols.

## 191. LAMIACEAE (Mint Family)

HEDEOMA HISPIDA Pursh C.

Roadside in Inverness Township, 1935.

LYCOPUS VIRGINICUS L. C.

Shore of Burt Lake west of Carp Creek, 1930.

## 192. ROSACEAE (Rose Family)

ROSA BLANDA HERMANNI Erlanson C.

Ice rampart, Duncan Bay, 1931. (Determined by E. W. Erlanson.)

ROSA RUBIGINOSA L. C.

Ballast of Michigan Central Railroad at Mill Creek, southeast of Mackinaw City, 1930.

RUBUS PERACER Bailey. *Gentes Herbarum*, 5: 492-494. 1944. C.

"Bank of stream, near University of Michigan Biological Station, Bailey 788."

RUBUS PARVIFLORUS Nutt. of our earlier list is now separated into *R. parviflorus hypomalacus* Fernald, previously listed, and *R. parviflorus bifarius* Fernald. The latter, from a limestone outcrop at Mill Creek, 1930 and later years, is new to the list. E.C.

SCHIZONOTUS SORBIFOLIUS (L.) Lindl. (*Sorbaria sorbifolia* (L.) A. Brown.) E.

Escaped from cultivation. Roadside two miles east of Bliss, 1931.

## 193. MALACEAE (Apple Family)

Amelanchier: The amelanchiers of our previous list have been further collected by J. H. Ehlers and reevaluated by K. M. Wiegand as follows:

*Plants of the Douglas Lake Region* 35

- AMELANCHIER BARTRAMIANA  $\times$  LAEVIS Wiegand? C.  
 East side of Smith's bog.
- AMELANCHIER LAEVIS Wiegand C.  
 Aspens south of Douglas Lake and Smith's bog region.
- AMELANCHIER LAEVIS  $\times$  STOLONIFERA Wiegand E.C.  
 Sandy ground vicinity of the Biological Station and Cecil — Big Stone Bay region.
- AMELANCHIER HURONENSIS Wiegand E.C.  
 Aspens in the vicinity of the Biological Station and openings in coniferous woods in Big Stone Bay region.
- AMELANCHIER HURONENSIS  $\times$  LAEVIS Wiegand (probably) C.  
 Aspens near the Biological Station and Smith's bog.
- AMELANCHIER HURONENSIS  $\times$  STOLONIFERA Wiegand? C.  
 Sandy ridge near the Biological Station.
- AMELANCHIER STOLONIFERA Wiegand E.C.  
 Jack-pine plains south of Burt Lake and dune region of north-western Emmet County.
- CRATAEGUS LUCORUM Sarg. C.  
 Jack-pine forest, 1930.

194. PRUNACEAE (Plum Family)

- PRUNUS AMERICANA Marsh. C.  
 Sandy soil at Yoeman's, Colonial Point, Burt Lake, 1932.

198. CASSIACEAE (Senna Family)

- GLEDITSIA TRIACANTHOS INERMIS Willd. E.  
 Hedgerow along U. S. Highway 31 between Brutus and Alanson 1932.

199. FABACEAE (Bean Family)

- LATHYRUS LATIFOLIUS L. E.C.  
 Roadside and railroad ballast north of Alanson, 1934. Cultivated and escaping at the Biological Station.
- LATHYRUS TUBEROSUS L. E.  
 Roadside along U. S. Highway 31 south of Carp Lake, 1935.
- VICIA DASYCARPA Ten. E.  
 Roadside along U. S. Highway 31 south of Carp Lake, 1936.

## 215. LYTHRACEAE (Loosestrife Family)

LYTHRUM SALICARIA L.

C.

Grassy swamp at outlet of Cheboygan River, 1933.

## 261. AESCULACEAE (Buckeye Family)

AESCULUS HIPPOCASTANUM L.

C.

Cultivated in Cheboygan.

## 262. ACERACEAE (Maple Family)

ACER SACCHARUM RUGELII Rehd.

C.

Woods along north shore of Burt Lake, 1931. (Additional to the species.)

## 269. JUGLANDACEAE (Walnut Family)

CARYA (probably C. GLABRA (Mill.) Spach.)

E.

Planted along a road east of Round (Lark) Lake; not fruiting, 1933.

## 270. BETULACEAE (Birch Family)

BETULA PUMILA L.

C.

In Chamaedaphne bog at Little Lake Sixteen, 1936. The variety *glandulifera* Regel is also present in the same area.

## 279. CAPRIFOLIACEAE (Honeysuckle Family)

LONICERA MORROWII A. Gray

E.

Escaping from cultivation. Along Pere Marquette Railroad near quarry at Bayview, 1931.

LONICERA TATARICA L.

E.

Escaping from cultivation. Along Pere Marquette Railroad near quarry at Bayview, 1931. Previously recorded in cultivation.

SYMPHORICARPOS OCCIDENTALIS Hook.

C.

At Michigan Central Railroad station at Topinabee, 1934.

SYMPHORICARPOS RACEMOSUS PAUCIFLORUS Robbins

E.C.

Previously recorded as the species from jack-pine plains south of Burt Lake. Sandy woods edging Lake Michigan at Lookout Point.

287-300. COMPOSITAE

287. HELIANTHACEAE (Sunflower Family)

HELIANTHUS HIRSUTUS Raf. C.

Cheboygan dumping ground, 1933.

RUDBECKIA LACINIATA L. E.C.

Banks of Sturgeon River south of Burt Lake, 1931; roadside ditch at southwestern corner of Emmet County, 1942.

288. AMBROSIACEAE (Ragweed Family)

AMBROSIA TRIFIDA INTEGRIFOLIA (Muhl.) Gray C.

Cheboygan dumping ground, 1935. (The species has previously been recorded from Emmet County.)

293. ASTERACEAE (Aster Family)

ASTER PANICULATUS BELLIDIFLORUS (Willd.) Burgess E.C.

Low ground in aspens along Maple River west of Douglas Lake, 1938.

296. ANTHEMIDACEAE

MATRICARIA SUAVEOLENS (Pursh) Buchenau E.C.

Cheboygan and dumping ground, 1936; along a road on the north shore of Carp Lake, 1935.

298. CARDUACEAE (Thistle Family)

CENTAUREA CYANUS L. C.

Cheboygan and the city dumping ground, 1935.

300. LACTUCACEAE (Lettuce Family)

SONCHUS ARVENSIS L. C.

Waste ground and fallow field, Cheboygan and vicinity, 1931 and later.

Also var. *glabrescens* Gunth., Graebner and Wimmer, in the same places, 1933 and later.

NEW RECORDS FOR EMMET COUNTY

Since the publication of the previous papers the species listed below have been found in Emmet County also.

**Phylum PTERIDOPHYTA****11. POLYPODIACEAE**

- DRYOPTERIS PHEGopteris** (L.) C. Chr. E.C.  
In Thuja woods along Pickerel Lake, 1933.

**Phylum ANTHOPHYTA****6. SPARGANIACEAE (Burreed Family)**

- SPARGANIUM AMERICANUM** Nutt. E.C.  
Crooked River, 1937; also in the Cecil Bay region, 1938.

**9. POTAMOGETONACEAE (Pondweed Family)**

- POTAMOGETON FOLIOSUS** Raf. E.C.  
Carp and French Farm lakes, 1933; a pond in Wilderness State Park.  
**POTAMOGETON HETEROPHYLLUS** f. **MYRIOPHYLLUS** (Robbins) Morong E.C.  
French Farm Lake, 1935.

**22. NAIADACEAE**

- NAIAS FLEXILIS** (Willd.) R. & S. E.C.  
Crooked River, 1932, and Sucker Creek, 1934.

**30. CYPERACEAE (Sedge Family)**

- CAREX PROJECTA** Mackenzie E.C.  
Big Stone Bay, 1924, and Lark Lake area, 1933.  
**SCIRPUS SUBTERMINALIS** Torr. E.C.  
French Farm Lake, 1930 and 1935.

**31. POACEAE (Grass Family)**

- AGROSTIS CAPILLARIS** L. E.C.  
Wet road at Wycamp Lake, 1931.  
**BRACHYELYTRUM ERECTUM** (Schreb.) Beauv. E.C.  
Thickets along Crooked River near Alanson, 1932. F. C. G. 17204.  
L. H. Harvey 418, 1937, in Harvey, 1940.  
**LEERSIA ORYZOIDES** (L.) Sw. E.C.  
Crooked River at Alanson, 1934. J. H. E. 5649. L. H. Harvey 510, 1937, in Harvey, 1940.

- PANICUM TSUGETORUM Nash E.C.  
 "Widespread on old vegetated sand dunes southeast of Sturgeon Bay. Harvey 683, 1938."

140. SALICACEAE (Willow Family)

- SALIX CORDATA Muhl. E.C.  
 Fore-dune ridge at Cecil, 1931.

169. BORAGINACEAE (Borage Family)

- CYNOGLOSSUM BOREALE Fernald E.C.  
 Open woods at Trail's End, Cecil Bay, 1930; north of Harbor Springs, 1937.

194. PRUNACEAE (Plum Family)

- PRUNUS ALLEGHANIENSIS DAVISII W. F. Wight. E.C.  
 Small tree in piny aspens east of Pellston, 1930.

224. HALORAGIDACEAE (Water Milfoil Family)

- MYRIOPHYLLUM VERTICILLATUM PECTINATUM Wallr. E.C.  
 Crooked River at Alanson, 1937.

287. HELIANTHACEAE (Sunflower Family)

- HELIANTHUS SUBRHOMBOIDEUS Rydb. (= *Helianthus rigidus* (Cass.) Desf.) E.C.  
 In aspens west of Douglas Lake, 1934.

293. ASTERACEAE (Aster Family)

- ASTER LINDLEYANUS T. & G. E.C.  
 Piny aspens east of Pellston, 1931.

NEW RECORDS FOR CHEBOYGAN COUNTY

Since the publication of the previous papers the species listed below have been found in Cheboygan County also.

6. SPARGANIACEAE (Burreed Family)

- SPARGANIUM ACAULE (Beeby) Rydb. E.C.  
 Muddy shores and shallow water, Penny Lake, 1932.



## 12. PONTEDERIACEAE (Pickerelweed Family)

- PONTEDERIA CORDATA L. E.C.  
Black Lake near its outlet, 1932.

## 30. CYPERACEAE (Sedge Family)

- ELEOCHARIS ROSTELLATA Torr. E.C.  
Margin of Twin Lakes, 1933, H. A. Gleason; also shore of Munro Lake.
- RYNCHOSPORA CAPILLACEA Torr. E.C.  
Sandy shore of Lake Huron southeast of Mackinaw City, 1938.
- RYNCHOSPORA FUSCA (L.) Ait. f. E.C.  
Wet sand, Vincent Lake, 1936.

## 31. POACEAE (Grass Family)

- BROMUS TECTORUM L. E.C.  
Railroad ballast and near-by roads, L. H. Harvey 519, 1937, in Harvey, 1940.
- CALAMOVILFA LONGIFOLIA (Hook.) Hack. E.C.  
Dunes along Duncan Bay, L. H. Harvey 427, 1937, in Harvey, 1940.
- ELYMUS VIRGINICUS L. E.C.  
Depression in aspens north of Tower, 1937, L. H. Harvey 239, in Harvey, 1940.

## 35. IRIDACEAE (Iris Family)

- SISYRINCHIUM ANGUSTIFOLIUM Mill. E.C.  
Shore of Lake Huron east of Duncan Bay, 1930.

## 45. ORCHIDACEAE (Orchid Family)

- LYSIAS HOOKERIANA (A. Gray) Rydb. (*Habenaria hookeriana*) E.C.  
Coniferous woods along Lake Huron east of Cheboygan, 1931, and in Benton Township, 1934.

## 104. EUPHORBIACEAE (Spurge Family)

- TITHYMALOPSIS COROLLATA (L.) Kl. & Garcke (*Euphorbia corollata* L.) E.C.  
Camping place near Penny Lake, 1931.

126. PAPAVERACEAE (Poppy Family)

PAPAVER RHOEAS L.

E.C.

Roadside south of Indian River, 1930.

132. BRASSICACEAE (Mustard Family)

ARABIS HOLBOELLII Hornem.

E.C.

Sandy shore of Lake Huron southeast of Mackinaw City, 1934.

BARBAREA STRICTA Andr.

E.C.

Shores of Lake Huron northwest of Cheboygan and of Mill Creek, 1936.

190. VERBENACEAE (Verbena Family)

VERBENA STRICTA Vent.

E.C.

Roadside near Penny Lake, 1932; Green Star Trail, Inverness Township, 1934.

199. FABACEAE (Bean Family)

LATHYRUS MARITIMUS (L.) Bigel.

E.C.

Although previously credited to Cheboygan County on the basis of plants persistent from seeds planted at the Biological Station, it grows naturally along Lake Huron north of Pries' Landing.

ROBINIA PSEUDOACACIA L.

E.C.

Planted behind the Biological Station and freely escaping.

276. AMMIACEAE (Carrot Family)

CONIUM MACULATUM L.

E.C.

Roadside along U. S. Highway 23 northwest of Cheboygan, 1930.

287. HELIANTHACEAE (Sunflower Family)

BIDENS FRONDOSA L.

E.C.

Wet sand, north shore of Burt Lake, 1923.

288. AMBROSIACEAE (Ragweed Family)

AMBROSIA TRIFIDA L.

E.C.

Colonial Point, 1932; Cheboygan and vicinity.

293. ASTERACEAE (Aster Family)

SOLIDAGO GILLMANI (A. Gray) Steele.

E.C.

Shores of Lake Huron east of Cheboygan, 1938.

- SOLIDAGO HOUGHTONII T. & G. E.C.  
Sandy beach of Lake Huron at Pries' Landing, 1931.  
SOLIDAGO OHIOENSIS Riddell E.C.  
Sandy beach of Lake Huron at Pries' Landing, 1931.

## 296. ANTHEMIDACEAE

- TANACETUM HURONENSE Nutt. E.C.  
Sandy beach of Lake Huron east of Cheboygan, 1931.

## 298. CARDUACEAE (Thistle Family)

- CARDUS CRISPUS L. E.C.  
Roadside north of Douglas Lake, 1933.

VERIFICATIONS OF EMMET COUNTY RECORDS BY FALLASS  
AND SWIFT

In the list published by the authors in 1925 some of the records for Emmet County (indicated by "E \*") were based solely on an unpublished list of Emmet County plants by Fallass and Swift. During the years subsequent to the appearance of "Additions I" and "Additions II" the presence of the following species in Emmet County has been verified by collections by our own.

**Phylum CALAMOPHYTA**

## 2. Equisetaceae (Horsetail Family)

- EQUISETUM PALUSTRE L. E.C.  
Crooked River at Alanson, 1934.

**Phylum ANTHOPHYTA**

## 6. SPARGANIACEAE (Burreed Family)

- SPARGANIUM EURYCARPUM Engelm. E.C.  
Crooked River at Alanson, 1932.  
SPARGANIUM MINIMUM Fries. E.C.  
Shallow water, French Farm Lake, 1935.

9. POTAMOGETONACEAE (Pondweed Family)

- POTAMOGETON PECTINATUS L. E.C.  
 French Farm Lake, 1930; Crooked River at Alanson, 1933.  
 POTAMOGETON PERFOLIATUS L. E.C.  
 Crooked River at Alanson, 1938.

30. CYPERACEAE (Sedge Family)

- CAREX LUPULINA Muhl. E.C.  
 Maple River thickets west of Pellston, 1931.  
 CAREX TRIBULOIDES Wahl. E.C.  
 West of Pellston, 1931.

31. POACEAE (Grass Family)

- AGROPYRON TENERUM Vasey E.C.  
 Aspens west of Douglas Lake, 1931.

45. ORCHIDACEAE (Orchid Family)

- LIPARIS LOESELLII (L.) Richards E.C.  
 Desiccated beach pool, Cecil Bay, 1936.  
 POGONIA OPHIOGLOSSOIDES (L.) Ker. E.C.  
 Desiccated beach pool, Cecil Bay, 1936.  
 SPIRANTHES GRACILIS (Bigel.) Beck E.C.  
 Edge of Lower O'Neal Lake, 1934.  
 SPIRANTHES ROMANZOFFIANA Cham. (*S. strictum*) E.C.  
 Edge of beach pool, Sturgeon Bay dunes, 1930.

60. RANUNCULACEAE (Buttercup Family)

- RANUNCULUS LONGIROSTRIS Godron (*Batrachium trichophyllum*  
 (Chaix) F. Schultz) E.C.  
 Sturgeon Bay and Crooked River at Alanson.

132. BRASSICACEAE (Mustard Family)

- BRASSICA NIGRA (L.) Koch E.C.  
 Rye field east of Trail's End, Cecil Bay, 1936.

133. CARYOPHYLLACEAE (Pink Family)

- AGROSTEMMA GITHAGO L. E.C.  
 Field west of Pellston.

## 169. BORAGINACEAE (Borage Family)

- LITHOSPERMUM OFFICINALE L. E.C.  
Wooded park at Mackinaw City, 1933.

## 172. OLEACEAE (Olive Family)

- FRAXINUS PENNSYLVANICA Marsh. E.C.  
Shore of Wycamp Lake, 1931.

## 178. SCROPHULARIACEAE (Figwort Family)

- MIMULUS GEYERI Torr. E.C.  
Bank of Maple River south of the dam, 1936.  
MIMULUS RINGENS L. E.C.  
Along Carp River at Cecil, 1931.

## 185. LENTIBULARIACEAE (Bladderwort Family)

- UTRICULARIA RESUPINATA B. D. Greene E.C.  
Northwest part of West Lake, north of Carp Lake, G. E. Nichols,  
1934.

## 192. ROSACEAE (Rose Family)

- GEUM CANADENSE Jacq. E.C.  
Beech-maple forest west of Pellston, 1931.  
POTENTILLA CANADENSIS L. E.C.  
Aspens west of Pellston, 1931.  
RUBUS CANADENSIS L. E.C.  
Margin of beech-maple forest, McGulpin Point, 1934.

## 237. VITACEAE (Grape Family)

- PARTHENOCISSUS QUINQUEFOLIA (L.) Planch E.C.  
Woods west of Pellston, 1930.

## 277. CORNACEAE (Dogwood Family)

- CORNUS AMOMUM Mill. E.C.  
Sandy ridge at Cecil Bay, 1931.

## 278. RUBIACEAE (Madder Family)

- GALIUM CIRCAEZANS Michx. E.C.  
Woods west of Pellston, 1930.

279. CAPRIFOLIACEAE (Honeysuckle Family)

- LONICERA GLAUCESCENS Rydb. E.C.  
Piny aspens west of Maple River, 1934.

283. CAMPANULACEAE (Bellwort Family)

- LOBELIA SIPHILITICA L. E.C.  
Along Maple River, 1931.

293. ASTERACEAE (Aster Family)

- SOLIDAGO ALTISSIMA L. E.C.  
Aspens west of Douglas Lake, 1938.  
SOLIDAGO CAESIA L. E.C.  
Wooded dunes south of Cross Village, 1930.  
SOLIDAGO SEROTINA Ait. E.C.  
Aspens west of Douglas Lake, 1938.

NEW RECORDS MADE BY THE SENIOR AUTHOR, 1938-45

Although travel was greatly restricted during most of the years after the retirement of Dr. Ehlers, nevertheless a few additions were made to the flora of the Douglas Lake region. To keep them separate from the work of the joint authorship they are given in the list below.

NEW RECORDS

- ULMUS PUMILA L. E.C.  
Planted at the Biological Station about 1936; has been dwindling for five years. Planted at Oden Fish Hatchery.  
PLANTAGO ARENARIA W. & K. E.  
Ballast of Pennsylvania Railroad Lines at Kegomic, 1945.  
F. C. G. 21568.  
THYMUS SERPYLLUM L. E.  
Waste area along U. S. Highway 31 north of Conway, 1945.  
F. C. G. 21571.  
GALIUM WIRTGENII F. Schultz E.  
Waste area along U. S. Highway 31 north of Conway, 1945.  
F. C. G. 21570. (First present about 1941.)

## ADDITIONS FROM CHEBOYGAN COUNTY

- AGROPYRON SMITHII Rydb. E.C.  
 Roadside in Hebron Township, 1942. F. G. G. 21431.  
 SALIX CANDIDA X DISCOLOR E.C.  
 Larix bog north of Mud Lake, 1940. F. C. G. 21157.

CONFIRMATION OF RECORDS BY FALLASS AND SWIFT  
 (Changes from E\* to E)

- EPIFAGUS VIRGINIANA (L.) Bart. E.C.  
 Beech-maple woods at Bayview, 1942. F. C. G. 21459.  
 ASTER NOVAE-ANGLIAE L. E.C.  
 Boggy ground bordering a lake north of Pleasant View, 1941.  
 F. C. G 21352.

TABLE I

## SUMMARY OF PHYLA

Phyla	Emmet County	Cheboy- gan County	Total		
			Families	Genera	Species and varieties
9. Pteridophyta .....	17	33	4	14	33
10. Calamophyta .....	11	13	1	1	14
11. Lepidophyta .....	7	9	2	2	10
13. Strobilophyta .....	12	12	2	8	12
14. Anthophyta .....	891	1053	115	435	1157
Monocotyledoneae .....	(297)	(347)	(19)	(111)	(379)
Dicotyledoneae-Axiflorae ..	(302)	(354)	(50)	(180)	(396)
Dicotyledoneae-Calyciflorae	(292)	(352)	(46)	(144)	(382)
Totals .....	938	1120	124	460	1226

The following families have 25 or more species in the region:

"Compositae" .. 129	Rosaceae ..... 43	Fabaceae ..... 28
Cyperaceae ..... 123	Orchidaceae ..... 38	Polygonaceae .. 27
Poaceae ..... 112	Lamiaceae ..... 30	Salicaceae ..... 26
Brassicaceae .... 43	Ranunculaceae .. 29	

The largest genus is Carex, with 91 species.

# A POSTGLACIAL PLANT SUCCESSION AT ANN ARBOR, MICHIGAN, DATING FROM THE HIGHEST LAKE MAUMEE LEVEL \*

ETHEL B. HANSEN

## INTRODUCTION

**D**URING the oscillating retreat of the last continental ice sheet new land areas were constantly being laid bare to the invasion of plants. To determine the identity of these pioneers and the plant successions that developed in the denuded areas is of importance, for it serves not only to unite the present vegetation with that of the past, but also to facilitate the interpretation of relict communities and postglacial climates.

An early postglacial deposit located in the roadside bank along Plymouth Road about one-quarter mile northeast of Calvary Evangelical Church (formerly known as Broadway Chapel), Ann Arbor, Michigan (Fig. 1), offered an opportunity for such an investigation. Although many of the fossils were poorly preserved and fragmentary, they provided the basis for a reconstruction of the biota in the Ann Arbor area as well as for a study of the development of the vegetation after the fall in level of the highest glacial Lake Maumee.

## ACKNOWLEDGMENTS

For kindly criticism I am indebted to Professor H. H. Bartlett, who found the deposit and directed me in the conduct of the investigation. I wish to thank those who made the following identifications: the fossil Mollusca, by Mr. Calvin Goodrich; the deer antler, by Dr. Lee R. Dice; the snail eggs and the surface Mollusca, by Dr. A. F. Archer; the moss, by Dr. W. C. Steere; the algae, by Dr. G. W. Prescott. To Dr. Gladys F. West I am grateful for

\* Papers from the Department of Botany of the University of Michigan, No. 515.



assistance in making the collections. But above everyone else I am under obligation to the late Dr. Frank Leverett, who interpreted the glacial geology of the region and wrote a detailed memorandum, illustrated by a map, on the position of the ice border.

#### GEOLOGICAL HISTORY

During the waning stage of the last or Wisconsin ice sheet the ice margin was formed into prominent lobes occupying the basins of the Great Lakes. This lobation was favored by the fact that the ice was thinner on the highlands and disappeared from them faster than in the basins of the Great Lakes between them.

Three large lobes of the Wisconsin ice sheet, the Huron-Erie, the Saginaw, and the Michigan, encroached upon the Southern Peninsula of Michigan. As the ice sheet halted in the northward retreat of its border, moraines were formed. These were arranged in loops adjacent to and lying concentrically with the borders of the lobes. The Huron-Erie and the Saginaw were the only lobes which touched the Ann Arbor quadrangle. As the Saginaw lobe of the glacier withdrew from the northwestern part of this quadrangle, it exposed part of the interlobate moraine formed between the Saginaw and the Huron-Erie lobes. On the Huron-Erie ice border were formed in succession the Fort Wayne moraine and the outer ridge of the Defiance moraine. Drainage was then down the Huron River and along the ice front to the Raisin River and southward into a pre-Defiance bay of glacial Lake Maumee at Tecumseh, Michigan. An outwash apron, on which the University of Michigan campus now stands, and the gravel deposits east of the Huron River in the north part of Ann Arbor were laid down at this time. As the Huron-Erie lobe shrank to the inner ridge of the Defiance moraine, the Huron and Raisin rivers continued to discharge into glacial Lake Maumee (Russell and Leverett, 1915).

After this period the ice border shrank eastward far enough to permit the extension of Lake Maumee to Ypsilanti and along a narrow bay or estuary up the Huron River Valley to Ann Arbor (Fig. 1). The backwaters of the highest stage of glacial Lake Maumee filled the Huron River Valley in the Ann Arbor area as far as the 800-foot contour line and thus formed an estuary extending over what is now the lowland along the Ann Arbor railroad in the northern part of the city. While it was flowing into the end of the estuary,





### LEGEND

+ MAUMEE DEPOSIT    A DELTAS OF HIGHEST (A) AND MIDDLE (B) MAUMEE GLACIAL LAKES



CONTOUR INTERVAL 20 FEET

FIG. 1. Map of Ann Arbor, showing location of the Maumee deposit near the railroad and of the deltas of the highest and the middle Maumee glacial lakes



the Huron River built a delta of the highest glacial Lake Maumee (A in Fig. 1).

Eventually, as the ice melted further, Lake Maumee found a lower outlet than that through Fort Wayne, which led across the "Thumb" of Michigan (Leverett and Taylor, 1915). The level of the estuary was lowered sufficiently to allow the lime-laden waters of the springs to seep down the gravel bank of the old Huron River into the bordering lower land at the site of the deposit and form a layer of tufa about two feet thick upon the Lake Maumee clay surface, at an elevation of 788 feet. There followed a succession of alternating layers of peat and tufa which built up the terrace bench, from 788 feet to 797½ feet, in which the fossil remains were preserved (Pls. I-II).

Dr. Leverett was greatly interested in the deposit described in this paper and personally prepared the map which is reproduced as Figure 2. A memorandum by him which accompanied the map is here repeated almost verbatim. The position of the ice border during the time the tufa deposit was being developed has been worked out not only in the southeastern part of Michigan, but also in the adjoining part of Ontario. The Birmingham moraine marks the position on the west side of the Huron ice lobe from Imlay City southward past Romeo, Rochester, and Birmingham. Between Birmingham and Detroit there is an interlobate moraine formed as the joint product of the Huron and the Erie ice lobes. This is called the Detroit Interlobate, and it has been traced by W. H. Sherzer across the Ontario Peninsula from Windsor, Ontario, to the north bluff of Lake Erie near Leamington in a southeastward course; the Huron lobe stood on its northeastern side while the Erie lobe stood on the southwestern side. The Huron lobe covered about thirty miles of the north bluff of Lake Erie east of Leamington, Ontario, as determined by Leverett, and forced the Lake Erie lobe to stay within the limits of the Erie bluff. A moraine forming the east border of the Huron lobe starts at the Lake Erie shore at Cedar Springs in Kent County and runs northward past Ridgetown and Highgate, and is traceable in that course through Middlesex County past Mt. Brydges. This correlates closely with the Birmingham moraine of southeastern Michigan. It is a matter of note that the Huron lobe formed a definite easily mappable moraine all around its border. In this respect it is decidedly in contrast with the Erie lobe.

The Erie lobe is represented in Wayne and Monroe counties in Michigan by bouldery strips in a featureless plain. These are not continuous, but are found in patches and short strips, as indicated by Sherzer in his maps of Wayne and Monroe counties. The outer boulder belt is called the Rawsonville moraine, since it is developed in the vicinity of that hamlet. The inner belt is called the Scofield moraine, from a small village situated on it in northern Monroe County (Fig. 2).

#### DETAILED DESCRIPTION OF THE DEPOSIT

The site of the tufa and peat deposit is shown in Plates I and II. It was exposed during the excavating for widening what is known as the Plymouth Road. The fresh exposure showed a series of highly irregular layers and lenses of peat interlarded with much more calcareous tufa than peat, the whole resting upon an impervious layer of Maumee Lake clay which formed a definite spring level. At the top of the sloping road cut is a railroad, and beyond the railroad the gently sloped surface of the terrace extends for one hundred and fifty feet from the edge of the road. Since higher levels on the same slope showed only gravel, it is obvious that the peat and tufa had been formed on the spring-fed sloping seepage surface inclined toward the level of the Plymouth Road. A thorough investigation of the deposit required digging a trench (Pl. V, Fig. 2) into the bank at a right angle to the road as far as possible without undermining the railroad right of way, the edge of which is marked by the line of fence posts shown in Plate I. On the other side of the railroad the deposit was explored by digging a series of postholes in line with the trench. The trench and postholes enabled the course of the more or less continuous strata to be followed. They were undulating and only slightly inclined up the slope, and their positions were determined by measurement and plotted to provide the basis for Figure 3. The figure is more useful than any number of photographs of the side walls of the trench would have been, because the trench was so narrow that photographs would have been too oblique and distorted.

In general, the sloped surface of the road bank did not indicate any intelligible trend of the layers. This was, of course, because the original Maumee Lake clay surface, upon which the organic deposits had been formed, had itself been hummocky and irregular.



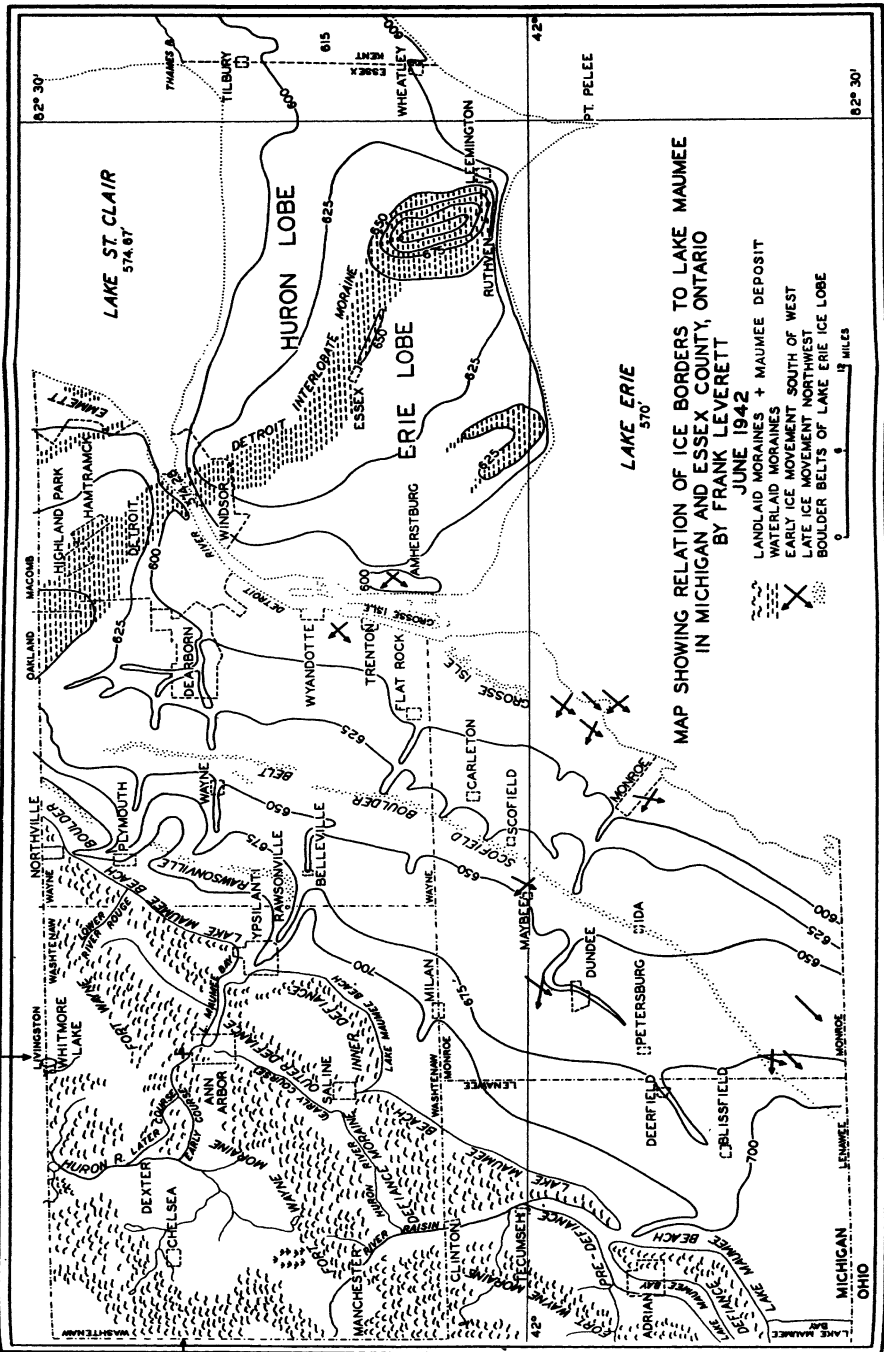






TABLE I

SAMPLES, FROM BOTTOM TO TOP, AT MIDDLE OF TRENCH IN WHICH  
FOSSIL SEEDS AND MOLLUSCA WERE FOUND

Sample No.	Depth				Layer shown in Figure 3	Embedding material
	From		To			
	ft.	in.	ft.	in.		
19	..	..	..	..	...	Surface
18	0	4	1	4	7c and 6e	Tufa and peat
17	1	4	1	10	7c	6 in. tufa
16	1	10	2	1	7c	Coarse tufa, no peat
15	2	1	2	6	7c and 6d	5 in. peat, some tufa
14	2	6	2	10	6c and 7c	4 in. tufa, some peat
13	2	10	3	2	7b and 6c	4 in. tufa, some peat
12	3	2	3	7	7b and peat lens	5 in. tufa, some peat
11	3	7	3	11	7b	4 in. coarse tufa
10	3	11	4	2	7a and 6b	3 in. coarse tufa, some peat
9	4	2	4	6	7a	4 in. coarse tufa
8	4	6	5	0	7a	6 in. coarse tufa
7	5	0	5	5	7a	5 in. coarse tufa
6	5	5	6	0	6a and 7a	7 in. peat and tufa
5	6	0	6	3	4	3 in. variegated peat
4	6	3	6	6	4	3 in. variegated peat
3	6	6	6	11	4	5 in. variegated peat
2	6	11	7	3	4	4 in. peat
1	7	3	9	0	2 and 3	Blue clay and coarse tufa

A number of photographs of the freshly beveled bank (Pls. I-II) show the highly irregular nature of the bedding when the deposit was sliced off along a quite precise inclined plane.

The vertical cut, which was carried back into the bank as the end face of the trench, was photographed when the trench was only begun. It is very informative, indeed, and is shown in Plates III and IV. The stratification was much clearer, and the chief layers were numbered in the hope that some of them could be traced continuously into the bank as the trench was extended (Pl. V, Fig. 2). Figure 3 shows the result of tracing the layers in the lateral wall of the trench and through the postholes.

The correlation of the layers in the trench and postholes was clearly indicated by their texture and color. The posthole highest up the slope was at an elevation of 808 feet 4 inches. At this point the Maumee clay base of the deposit was 4 feet below the ground

TABLE II

VERTICAL DISTRIBUTION OF FOSSIL SEEDS, SPORES, LEAVES, AND WOOD

Abbreviations: l, leaves; o, spores; s, seeds; t, trichoblast; w, wood

Number of sample in deposit (see Table I)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Fungi .....	.	.	o	o	.	.	.	.	.	.	o	o	o	o	o	o	.	.
Sphagnum .....	.	.	o	o	l	l	l	l	.	.	.	.	.	.	.	.	.	.
Musci .....	.	.	.	.	o	o	.	o	.	.	o	o	.	.	.	o	.	o
Amblystegium sp. ....	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	l
Polypodiaceae .....	.	.	o	o	.	o	o	o	.	.	o	o	o	o	o	o	o	o
Pteris aquilina L. ....	.	.	.	.	.	.	.	.	.	.	o	o	.	.	.	.	.	o
Pinus Strobus L. ....	.	.	.	.	.	.	.	.	.	.	.	.	.	w	.	w	.	.
Larix laricina (DuRoi) Koch (stem) .....	.	w	w	w	w	.	.	w	.	.	w	w	.	w	w	w	.	.
Larix laricina (DuRoi) Koch (root) .....	.	.	.	w	w	.	.	.	.	.	w	.	.	w	.	.	.	.
Picea canadensis (Mill.) BSP. ....	.	w	.	w	.	.	.	.	.	.	w	.	.	.	s	.	.	.
Picea mariana (Mill.) BSP. ....	.	w	w	w	.	.	w	w	.	.	w	.	.	w	w	w	.	.
Abies balsamea (L.) Mill. ....	.	w	w	w	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scirpus sp. ....	.	s	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex retrorsa Schwein. ....	.	s	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Quercus alba L. ....	.	.	.	.	.	.	.	.	.	.	.	.	.	w	.	.	.	.
Nymphaeaceae .....	.	t	.	t	.	.	.	t	.	.	.	.	.	.	.	.	.	.
Rubus idaeus var. aculeatissimus [C. A. Mey.] Regel & Tiling (?) ..	.	s	.	.	.	.	.	.	.	.	s	.	.	.	s	.	.	.
Rubus occidentalis L. (?) .....	.	.	.	.	.	.	.	.	.	.	s	.	.	.	.	.	.	.
Rubus allegheniensis Porter (?) ..	.	.	s	.	.	.	.	.	.	.	s	.	s	.	s	.	.	s
Zanthoxylum americanum Mill. ....	.	.	.	.	.	.	.	.	.	.	.	.	.	s	.	.	.	.
Vitis vulpina L. ....	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	s
Fraxinus nigra Marsh. ....	.	.	.	.	.	.	.	.	.	.	.	.	.	.	w	.	.	.
Sambucus canadensis L. ....	.	.	.	.	.	.	.	.	.	s	s	.	s	s	s	.	.	.
Sambucus racemosa L. ....	.	.	.	.	.	.	.	.	.	.	.	s	.	s	.	.	.	.

surface, at an elevation of 804 feet 4 inches. For 106 feet from the edge of the road the depth of the Maumee Lake clay varied slightly, but rose sharply in the remaining 44 feet up the original hill slope (Pl. V, Fig. 1).

The calcareous tufa layers above the lowest were vaguely but very discontinuously marbled or stratified, having more or less discoloration dependent upon the peat content. It was impossible to show this condition in Figure 3, because of the small size, the irregularity, and the variability of the minor peaty tufa lenses.

## PLANT REMAINS FOUND IN THE DEPOSIT

Although specific identification of the fossils was highly desirable, it was often impossible because of their fragmentary or distorted



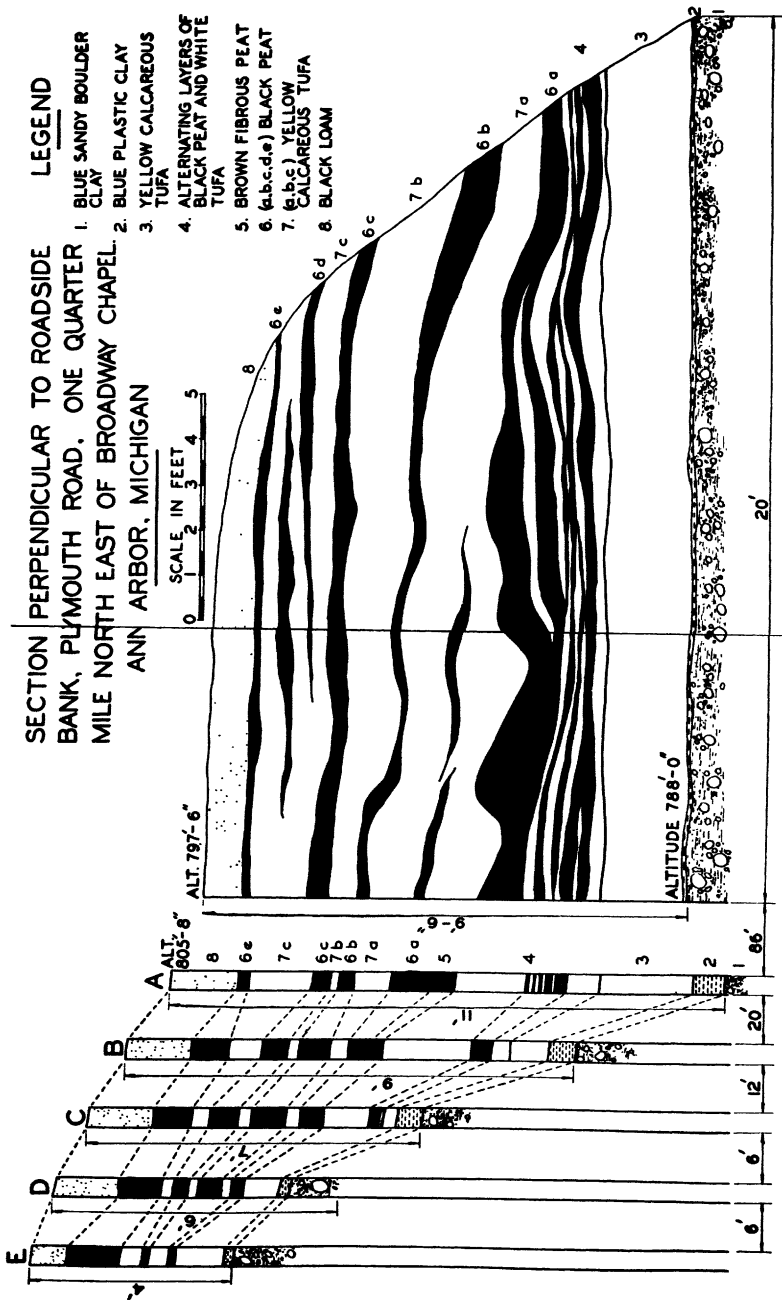


FIG. 3. Diagram showing strata of tuffa and peat in Maumee terraces at Ann Arbor, Michigan, as disclosed in trench and potholes A, B, C, D, and E.



condition. The snail eggs found in the deposit, together with the shells and a deer antler, were identified to the species. Some of the pollen, most of the seeds, and all the woods were identified to the species. The remainder of the pollen was identified to the genus or (in one group) to the family (Betulaceae). Although this family was treated as a unit in the pollen percentage counts, the component genera received consideration in the discussion.

The amount and kind of fossil evidence often differed for each plant; for example, the water lily was represented by internal trichomes (trichoblasts); *Sphagnum*, by spores and leaves; the bracken fern, *Pteris aquilina*, by sporangia; the bramble, *Rubus*, by pollen and seeds; the willow, *Salix*, by pollen; the tamarack, *Larix laricina*, by pollen and wood, and the white pine, *Pinus Strobus*, by wood (Tables I-II). The ecological significance of the fossils was of paramount importance in this investigation (Cain, 1944).

## CLASSIFICATION OF THE PLANT FOSSILS

### THALLOPHYTA

#### FUNGI

Spores.

### BRYOPHYTA

#### SPHAGNACEAE

*Sphagnum* sp.

Spores and leaf fragments. Common in bogs.

#### AMBLYSTEGIACEAE

*Amblystegium* sp.

Portion of leaf of this moss.

### PTERIDOPHYTA

#### POLYPODIACEAE

*Pteris aquilina* L. (Bracken fern)

Spores and sporangia. This fern is common in thickets and on hillsides; invades burnt-over forests of Michigan.

## SPERMATOPHYTA

## PINACEAE

*Pinus Strobus* L. (White pine)

(Plate VI, Fig. 1)

Safely, 1867; Penhallow, 1896, 1899; Hollick, 1906; West, 1948.

Pollen and wood. Formerly dominant as far south as Van Buren County, Michigan; a few relict trees are found at Howell, Michigan, about twenty-five miles north of Ann Arbor.

*Pinus Banksiana* Lamb. (Northern scrub pine)

Pollen. The characteristic tree of the sand plains in the northern part of the Southern Peninsula; absent from Washtenaw County.

*Larix laricina* (DuRoi) Koch (Tamarack)

(Plate VI, Fig. 2)

Safely, 1867; Dawson and Penhallow, 1890; Keyes, 1893; MacBride, 1896; Penhallow, 1896, 1899, 1904; Calvin, 1898; Coleman, 1899; Tarr, 1904; Baker, 1920; Cooper and Foot, 1932; Brown, 1938; West, 1948.

Pollen and wood. This tree is abundant in swampy areas and bogs in Michigan.

*Picea* sp. (Spruce)

Pollen.

*Picea canadensis* (Mill.) BSP. (White spruce)

Safely, 1867; Baker, 1920; Cooper and Foot, 1932; Wilson, 1932; Hansen, 1935; Brown, 1938.

Seed and wood. A dominant tree of the *Picea-Abies* association in the northern part of the Northern Peninsula; infrequent in bogs. Extends along the Lake Huron shore from Bay City to Mackinaw City, Michigan.

*Picea mariana* (Mill.) BSP. (Black spruce)

(Plate VII, Fig. 1)

Safely, 1867; Green, 1870; Bain, 1895; Coleman, 1899; Baker, 1920; Cooper and Foot, 1932; Wilson, 1932.

Pollen and wood. Abundant in tamarack and cedar bogs, and may be found as a rare relict in the vicinity of Ann Arbor.



*Abies balsamea* (L.) Mill. (Balsam fir)

(Plate VII, Fig. 2)

Coleman, 1895; Baker, 1920.

Pollen and wood. Balsam fir is one of the dominants of the climax forest in Isle Royale. Port Austin in Huron County is its southern limit in Michigan.

*Tsuga canadensis* (L.) Carr. (Hemlock)

West, 1948.

Pollen. One of the dominants of beech-maple forests in the northern part of the Southern Peninsula of Michigan. Extends as far south as Port Huron on the eastern side.

*Thuja occidentalis* L. (Arbor vitae)

Dawson and Penhallow, 1890; Baker, 1920; Brown, 1938; West, 1948.

Pollen. Dominant tree in cedar bogs of Michigan. Extends as far south as St. Clair County (Gates and Ehlers, 1924), and to the Waterloo area of Washtenaw and Jackson counties, where it is a rare relict.

TYPHACEAE

*Typha* sp. (Cattail)

West, 1948.

Pollen. Common in edges of bogs and ditches.

NAJADACEAE

*Potamogeton* sp. (Pondweed)

Pollen. Three species frequently found in ponds and quiet streams.

CYPERACEAE

*Eleocharis* sp. (Spike rush)

West, 1948.

Pollen. Four species common in shallow water.

*Scirpus sp.* (Bulrush)

(Plate VIII, Fig. 1)

Brown, 1938.

Pollen and achene. Four species abundant and sometimes dominant in aquatic associations.

*Carex sp.*

Dawson and Penhallow, 1890; Penhallow, 1900; Berry, 1924, 1933; Brown, 1938; West, 1948.

Pollen. Fifty species found in different habitats in Washtenaw County.

*Carex retrorsa* Schwein. (Sedge)

(Plate VIII, Fig. 2)

West, 1948.

Achene. One of the commonest sedges in Michigan.

## GRAMINEAE

Pollen.

## SALICACEAE

*Salix sp.* (Willow)

Brown, 1938; West, 1948.

More than one species seems to be present. Seven species common in county.

*Populus sp.* (Poplar)

Pollen. Three species frequently found in this area.

## JUGLANDACEAE

*Juglans sp.* (Walnut)

Brown, 1938.

Pollen.

*Carya sp.* (Hickory)

Brown, 1938; West, 1948.

Pollen. Four species common in the oak-hickory forest of southern Michigan.

BETULACEAE

*Corylus* sp. (Hazelnut)

*Betula* sp. (Birch)

*Alnus* sp. (Alder)

Pollen.

FAGACEAE

*Fagus* sp. (Beech)

Hollick, 1906; Berry, 1907, 1914, 1926, 1933; Emerson, 1917; Baker, 1920; West, 1948.

Pollen. *Fagus grandifolia* is a dominant in the beech-maple forest of the northern two thirds of Michigan; common on rich soil.

*Quercus* sp. (Oak)

West, 1948.

Pollen. At least six species very common.

*Quercus alba* L. (White oak)

(Plate IX, Fig. 2)

Penhallow, 1904; Berry, 1907, 1912; Emerson, 1917.

Pollen and wood. Common in oak-hickory forests of Washenaw County.

URTICACEAE

*Ulmus* sp. (Elm)

Penhallow, 1896, 1899, 1907; Brown, 1938.

Pollen. Two species found along rivers.

NYMPHAEACEAE

Trichoblasts.

ROSACEAE

*Rubus idaeus* var. *aculeatissimus*

[C. A. Mey.] Regel & Tiling (?) (Wild red raspberry)

(Plate VIII, Fig. 3)

Berry, 1907, 1914, 1924, 1926, 1933; Brown, 1938; West, 1948.

Seeds. Occurs in the northern part of the Southern Peninsula in burnt-over beech-maple land and in other associations; common in dry soil.

*Rubus occidentalis* L. (?) (Black raspberry)

(Plate VIII, Fig. 5)

Seeds. Frequent in woods and along fence rows in the vicinity of Ann Arbor.

*Rubus allegheniensis* Porter (?) (Blackberry)

(Plate VIII, Fig. 4)

West, 1948.

Seed. Dominant in bramble association, especially on sandy soil in the northern part of the Southern Peninsula; infrequent in present flora of Washtenaw County.

*Prunus* sp.

Brown, 1938.

Pollen. Two species common in county.

## RUTACEAE

*Zanthoxylum americanum* Mill. (Prickly ash)

(Plate VIII, Fig. 9)

West, 1948.

Seed. Found in rocky woods and along river banks in Washtenaw County.

## ACERACEAE

*Acer* sp. (Maple)

Dawson and Penhallow, 1890, Emerson, 1917; West, 1948.

Pollen. More than one species seems to be present. Seven species are found in present flora.

## VITACEAE

*Vitis vulpina* L. (River-bank grape)

(Plate VIII, Fig. 8)

Brown, 1938; West, 1948.

Charred seed. This grape grows along stream banks or near water; infrequent in Washtenaw County.

TILIACEAE

*Tilia* sp. (Basswood)

Penhallow, 1899, 1907; West, 1948.

Pollen: Common in rich woods.

ONAGRACEAE

*Epilobium* sp. (Fireweed)

Pollen. Probably *E. angustifolium*, which invades clearings and newly burned ground; frequent.

OLEACEAE

*Fraxinus* sp. (Ash)

Penhallow, 1899, 1900; Brown, 1938.

Pollen.

*Fraxinus nigra* Marsh. (Black ash)

(Plate IX, Fig. 1)

Penhallow, 1899; West, 1935, 1948.

Wood, probably pollen. Infrequent in this locality; common in swamps and river bottoms in northern Michigan.

CAPRIFOLIACEAE

*Sambucus canadensis* L. (Common elder)

(Plate VIII, Fig. 7)

Berry, 1924, 1933; Brown, 1938; West, 1948.

Seeds. Common in rich soil, open places.

*Sambucus racemosa* L. (Red-berried elder)

(Plate VIII, Fig. 6)

West, 1948.

Seeds. Infrequent in this locality.

COMPOSITAE

*Ambrosia* sp. (Ragweed)

Pollen.

*Erechtites* sp. (Fireweed)

Pollen. May represent *E. hieracifolia*, which comes in after burns. Frequent in woods.

## MOLLUSCA OF THE DEPOSIT

The tufa and likewise the peat contain a vast number of mollusks which were identified by Mr. Calvin Goodrich, emeritus curator of Mollusca in the Museum of Zoology, University of Michigan.

The mollusks were picked out of the embedding matrix of nineteen samples (Table I) taken from the middle of the trench shown in Figure 3. They afford an interesting record of vertical distribution (Table III).

TABLE III

VERTICAL DISTRIBUTION OF THE FOSSIL AND RECENT MOLLUSCA,\* FROM THE BOTTOM (SAMPLE 1) TO THE TOP OF THE DEPOSIT AND INCLUDING THE SURFACE (SAMPLE 19)

Number of sample from deposit (see Table I)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Terrestrial Species																			
<i>Anguispira alternata</i> (Say) ..												+			+		+		+
<i>solitaria</i> (Say) .....																			+
<i>Carychium exiguum</i> (Say) ..			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>exile</i> (Lea) .....										+		+			+			+	
<i>Cochlicopa lubrica</i> (Müller) ..			+	+	+					+		+	+	+	+	+	+		+
<i>Euconulus chersinus polygyratus</i> (Pilsbry) .....	+		+	+	+		+	+		+		+	+	+	+	+	+		+
<i>Gastrocopta armifera</i> (Say) ..			+							+								+	
<i>contracta</i> (Say) .....			+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+
<i>pentodon</i> (Say) .....					+	+													
<i>Gastrodonta ligera</i> (Say) ..											+		+						+
<i>Gonodiscus cronkhitei anthonyi</i> (Pilsbry) .....	+		+		+		+			+		+	+	+	+	+	+	+	+
<i>cronkhitei anthonyi</i> (Pilsbry) ? (eggs) .....											+		+						
<i>Hawaiiia minusculus</i> (Binney) ..					+				+			+			+	+	+	+	
<i>Helicodiscus parallelus</i> (Say) ..									+		+	+	+	+		+	+	+	
<i>Polygyra albolabris</i> (Say) ..																			+
<i>fraterna</i> (Say) .....																			+
<i>fraudulenta</i> (Pilsbry) .....																			+
<i>hirsuta</i> (Say) .....																			+
<i>inflecta</i> (Say) .....																			+
<i>monodon</i> (Rackett) .....	+									+	+		+	+	+	+	+	+	+
<i>profunda</i> (Say) .....												+						+	+
<i>thyroidus</i> (Say) .....																+			+
<i>tridentata</i> (Say) .....															+				+

Number of sample from deposit (see Table I)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
<i>Pupoides marginatus</i> (Say) ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	..
<i>Retinella hammonis</i> (Ström) .	+	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..
<i>indentata</i> (Say) .....	+	+	+	..	+	..	+	+	+	+	+	+	+	+	+	+	+	+	..	..
<i>Striatura exiguum</i> (Stimpson)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	..
<i>milium</i> (Morse) .....	+	..	+	+	..	..	..	..	..	..	..	+	+	+	+	+	+	..	..	..
<i>Strotilops affinis</i> (Pilsbry) ...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+
<i>labyrinthica</i> (Say) .....	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..
<i>labyrinthica virgo</i> (Pilsbry)	..	..	+	+	+	..	..	..	..	..	..	+	+	+	+	+	+	+	+	..
<i>Succinea avara</i> (Say) .....	+	..	..	..	..	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>ovalis</i> (Say) .....	..	..	..	..	..	..	..	..	..	..	+	+	..	+	..	+	+	+	+	+
<i>retusa</i> (Lea) amphib. ....	+	..	+	+	+	+	+	+	+	..	..	..	+	..	..	..	+	+	+	..
<i>Vallonia pulchella</i> (Müller) ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	..
<i>Vertigo gouldii</i> (Binney) ....	..	..	+	+	..	..	..	..	+	+	+	+	..	+	+	+	+	..	..	..
<i>morsei</i> (Sterki) .....	..	..	..	+	+	..	..	..	+	+	+	..	..	..	..	..	..	..	..	..
<i>ovata</i> (Say) .....	..	..	..	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	..
<i>tridentata</i> (Wolf) .....	..	..	..	..	..	..	..	..	..	..	..	..	+	+	+	+	+	..	+	..
<i>ventricosa</i> (Morse) .....	+	+	+	+	+	..	+	+	+	..	..	+	+	+	+	+	+	+	+	..
<i>Vitrea indentata</i> (Say) .....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+
<i>Zonitoides arboreus</i> (Say) ...	..	..	..	+	..	..	..	+	..	..	..	..	+	+	..	+	..	..	..	+
<i>milium</i> (Morse) .....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+
Bog or fresh-water species																				
<i>Gyraulus parvus</i> (Say) .....	+	..	..	+	+	..	+	+	+	..	+	..	+	+	+	+	+	+	+	..
<i>Lymnaea dalli</i> (Baker) .....	..	..	..	..	..	..	..	+	+	+	+	+	+	+	+	+	+	+	+	..
<i>humilis modicella</i> (Say) ..	..	..	..	..	+	..	+	+	+	..	..	..	+	+	..	..	..	..	..	..
<i>obrussa</i> (Say) .....	+	..	..	..	..	..	+	+	+	..	..	..	..	+	+	..	..	..	..	..
<i>Physa gyrina</i> (Say) .....	..	..	..	..	..	..	..	..	..	..	..	+	..	..	..	..	..	..	..	..
<i>Pisidium</i> sp. ....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	..	..
<i>Pomatiopsis lapidaria</i> (Say) ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	+

Ninety per cent of the Mollusca of the deposit proved to be terrestrial, and this is true even of the lowest layer. All the species are living, and none shows any significant deviation from the living representatives.

The few fresh-water species (pulmonates, with the exception of the ctenobranchiate *Pomatiopsis lapidaria*) are such as might occur in very shallow water, as at the edge of the deposit in its initial stages or in pools among the hummocks of the irregular surface later on.

The great numbers of specimens of *Carychium* indicate a continuously wet situation, as does *Strotilops* to a lesser degree. A common habitat for *Vertigo* in the Ann Arbor region today is the steep banks of ravines, where seepage permits a thick growth of mosses.

The following land species are typical in peat bogs:

<i>Carychium exiguum</i> (Say)	<i>Succinea avara</i> (Say)
<i>Carychium exile</i> (Lea)	<i>Succinea retusa</i> (Lea)
<i>Helicodiscus parallelus</i> (Say)	<i>Vertigo</i> spp.
<i>Polygyra monodon</i> (Rackett)	<i>Vitrea hammonis</i> (Ström)
<i>Strobilops labyrinthica</i> (Say)	<i>Vitrea indentata</i> (Say)

The Mollusca collected at the very surface make a long list, and all but the following are also found buried in the deposit:

<i>Anguispira solitaria</i> (Say)	<i>Polygyra fraterna</i> (Say)
<i>Polygyra albolabris</i> (Say)	<i>Polygyra inflecta</i> (Say)
<i>Strobilops affinis</i> (Pilsbry)	

These species may have existed a hundred years ago, when the forest was cleared. Only one of those on top of the deposit was found alive, namely, *Anguispira alternata* (Say). The surface (i.e. Recent) shells were identified by Dr. Allen Archer and are recorded in Column 19 of Table III.

In addition to the species listed from the trench, the postholes and other places yielded records of the following species, which were not definitely placed in the vertical sequence:

<i>Euconulus fulvus</i> (Müller)	<i>Retinella electrina</i> (Gould)
<i>Lymnaea</i> sp., probably <i>L.</i>	<i>Valvata tricarinata</i> (Say)
<i>palustris</i> (Müller)	<i>Vitrea indentata</i> (Say)
<i>Polygyra hirsuta</i> (Say)	<i>Zonitoides ligerus</i> (Say)
<i>Zonitoides milium</i> (Morse)	

#### INTERPRETATION OF THE DEPOSIT

Silt sinking from glacial waters to the bottom of the estuary formed an impervious layer of clay. By the opening of a lower outlet farther to the northeast, across the "Thumb" of Michigan, the level of glacial Lake Maumee was lowered and likewise the level of the estuary.

The rainfall of the adjoining upland collected in this part of the gravel catchment basin of the Huron River and flowed from the spring level of this bank and over the impervious Lake Maumee clay as the level of the estuary was lowered.

The plants growing in these spring waters all the way down the slope afforded a suitable substratum for lime-depositing organisms, which covered them with a layer of lime. As the vegetation decayed, cavities were left which gave to the tufa its characteristic porous texture. It was probably in this manner that the calcareous layers of the terrace were formed (Pls. II-III). Even at the present time



tufa is still being formed at the site of the deposit. A small rill of spring water, which flows along the roadside bank, is choked throughout most of its course by dense mats of *Chara* (probably *C. vulgaris*). The large number of land shells (90 per cent) found in the deposit gave additional evidence that most of it was formed in seepage water of little depth.

Considerable time probably elapsed before about two feet of basal tufa was formed on the glacial lake clay (Fig. 3, Stratum 3). As the climate became drier, the ground water level was lowered, and many of the springs ceased to flow and produce tufa. Conditions thus became favorable for the growth of bog plants which, during an unknown interval of time, built up a layer of peat on the tufa. It is possible that each layer of tufa was formed during periods of increased moisture, which would augment the volume of water flowing from the lime-charged springs, while, on the other hand, each continuous layer of peat may represent a period of decreased moisture, with conditions favorable for the growth of a bog flora (Clements, 1916).

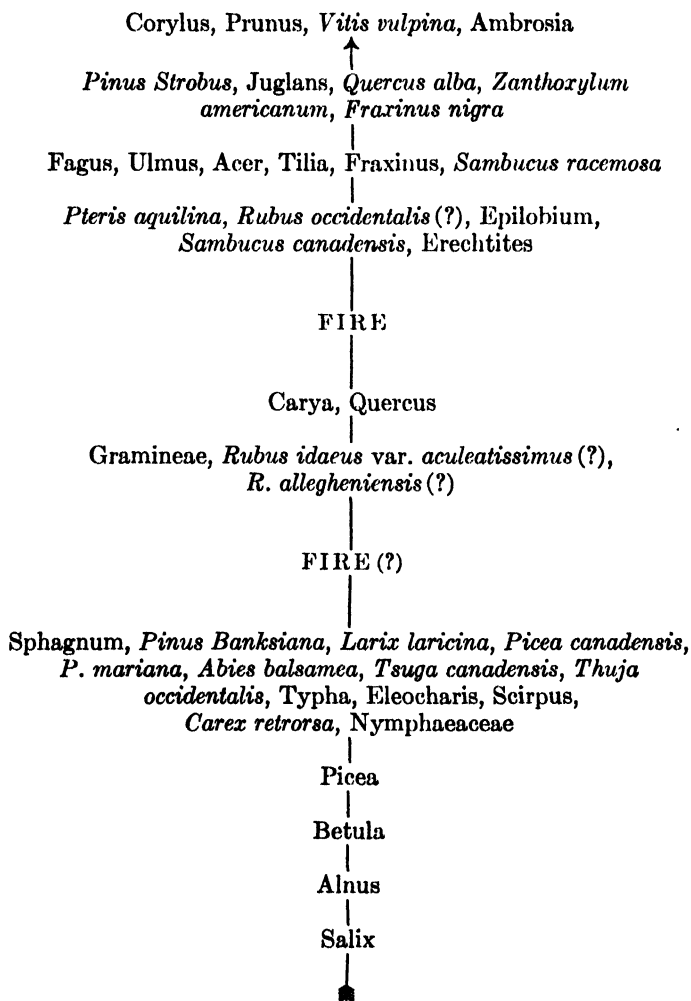
An examination of the lowest tufa (Fig. 3) gave no evidence of the first pioneers on the land surface recently exposed by the melting glacier, but a thin gray lens of peat included within the tufa contained the pollen of alder, birch, willow, hemlock, spruce, and pine. The significance of this group of pioneer trees may be clarified by the reports of scientists who have studied the development of vegetation in Alaska. Raymond Taylor (1932) states that at Glacier Bay, Alaska, "Pure stands of spruce . . . seem to be sub-climax and are characterized . . . by a sterile sandy soil covered by a mull composed of the debris of alder, willow, and poplar." It is altogether possible that these deciduous trees may have played a similar rôle in preparing the soil for the spruce seedlings in this early postglacial forest. By the use of permanent quadrats Cooper (1939) has studied vegetational development at Glacier Bay, Alaska. He found that the pioneer community consisted of mosses, *Epilobium*, *Equisetum*, *Dryas*, and prostrate willows. The next stage was the willow-alder thicket, and the final and climax stage had as dominants the Sitka spruce, *Picea sitchensis*, and two hemlocks, *Tsuga heterophylla* and *T. Mertensiana*. Baxter and Wadsworth (1939), in a study of transects on bars of the lower Yukon River at Koyukuk, Alaska, found that the order of succession was willow, poplar, alder, birch, and spruce. It is likely that willows were the

first trees to advance into this region and that they were followed by alder, birch, spruce, hemlock, and pine (Table IV).

TABLE IV

PROBABLE ORDER OF PLANT SUCCESSION AT ANN ARBOR, MICHIGAN,  
AFTER RETREAT OF THE WISCONSIN GLACIER (MOST RECENT  
PLANTS AT TOP)

(Groups arranged systematically)



The layer of peat that lies just above the basal tufa (Fig. 3, lower part of layer 4) contained pollen, spores, seeds, wood (Fig. 4), and shells. From the identified fossils it may be inferred that a bog, with its characteristic zones of plant life, occupied the margin of the estuary. There were water lilies floating in the water. Sedges, including *Carex retrorsa*, together with a spikerush, *Eleocharis*, cat-tails, *Typha*, and a bulrush, *Scirpus*, grew in shallower water behind the lilies. *Sphagnum* formed tufts among the sedges. Tamarack, *Larix laricina*, and the black spruce, *Picea mariana*, were dominant trees of the bog, which also supported the balsam fir, *Abies balsamea*,



FIG. 4. Coniferous wood from variegated peat layer (Fig. 3, Stratum 4), Maumee deposit. The rule is one foot long

the white spruce, *Picea canadensis*, and arbor vitae, *Thuja occidentalis*. On well-leached gravel or sandy ridges grew the northern scrub pine, *Pinus Banksiana*. There were clumps of hemlock, *Tsuga canadensis*, on lower ground, and along the watercourses were willows and alders. Birds may have dropped near the bog the seeds of the red raspberry, *Rubus idaeus* var. *aculeatissimus*(?), and the blackberry, *R. allegheniensis*(?) growing on the border of the approaching oak-hickory forest (Figs. 5-6, 95 in.).

Thus in the peat layer upon the basal tufa was preserved evidence not only of the presence of a bog with its characteristic zones of plant life, but also of the northern coniferous forest with its pioneers, and a vanguard of shrubs heralding the approach of the deciduous forest.

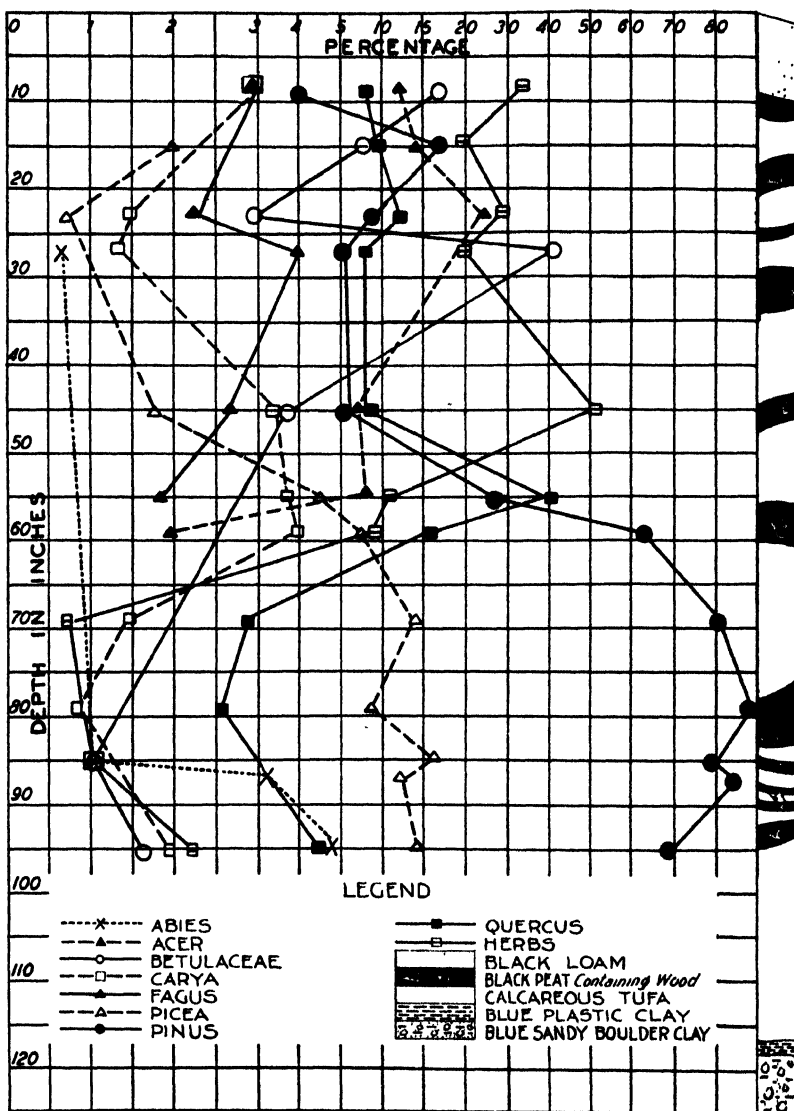


FIG. 5. Pollen diagram of Maumee terrace, indicating the development of vegetation at the site of Ann Arbor, Michigan, after the retreat of the Wisconsin glacier

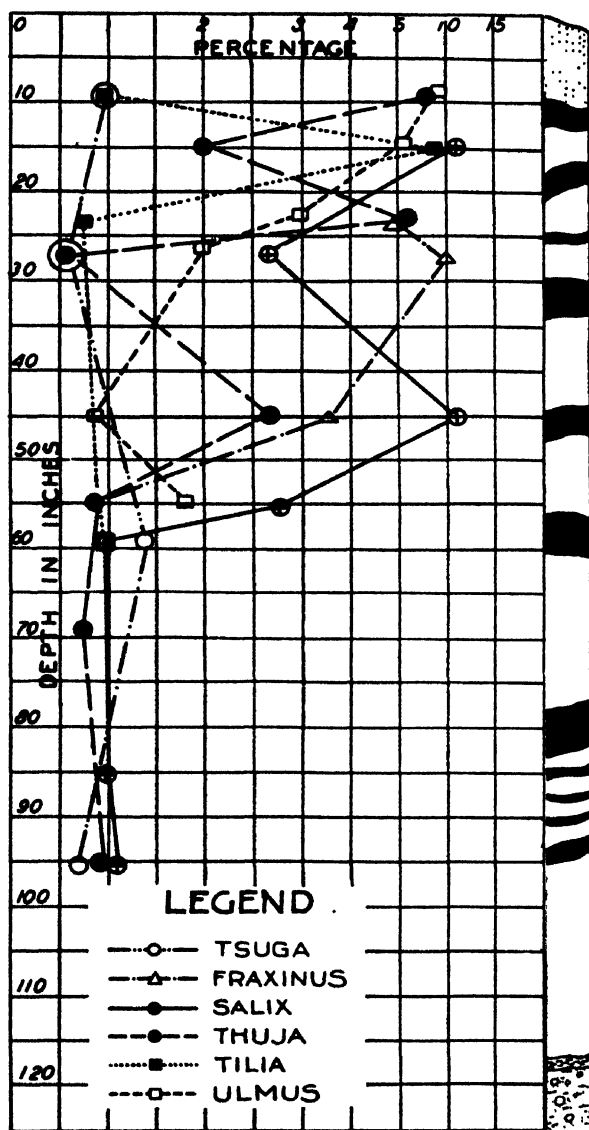


FIG. 6. Pollen diagram of Maumee terrace, indicating the development of vegetation at the site of Ann Arbor, Michigan, after the retreat of the Wisconsin glacier

The ice front, which had receded to a line east of Ypsilanti, was over twelve miles distant when the northern conifers entered and later reached their maximum development at Ann Arbor. It is probable, therefore, that zones of both tundra and scrub separated the northern coniferous forest from the margin of the ice sheet.

The proximity of the Wisconsin glacier during the period of shrinkage and waste would not require one to believe that southern Michigan had a boreal climate when the northern conifers occupied the region; on the contrary, it is likely that the climate was no more rigorous than that of northern Michigan today.

After the maximum development was attained by the coniferous forest (Fig. 5, 95 in.) the pines alone began a gradual increase until they became by far the most abundant trees in the area. There was a similar decrease in the deciduous trees which had entered the region. The increase in pines is believed to have taken place during a long dry period of peat formation. Although charred plant material was not found in this layer of peat, fires may have occurred in the surrounding region. They probably destroyed the seedlings of the invading oaks and other hardwoods, and may have provided conditions favorable for dominance of the fire-tolerant pines. Studies on the effect of fire on longleaf and slash pines in South Carolina and Louisiana by Frank Heyward (1939) show that thousands of acres of longleaf pine owe their dominance to tolerance of fire which destroyed seedlings of the invading hardwoods. A few pollen grains of grasses, Gramineae, were present here and also in the top stratum of the deposit.

After the pines had reached a maximum (Fig. 5, 79 in.) there occurred a gradual change in the facies of the formation. The deciduous trees, competing successfully with the conifers, increased at their expense. Finally, the oaks became dominant (Fig. 5, 55 in.), with pines ranking next in abundance. Hickory, although increasing in percentage, still lagged behind the dominant oak. Besides a few elms along the river there were maples and beeches growing in well-drained rich soil in the forest.

Forest fires are known to have occurred in the Pleistocene, and there is evidence of them in this area in the form of charcoal fragments and a charred seed found in the deposit. Coleman (1895) wrote: "It appears that forest fires raged in Ontario then as now,

for fragments of charcoal or chips charred on one edge are not infrequently found mixed with quite uncarbonized woody material."

While the oaks were dominant, a fire swept the country, as is indicated by charcoal found 55 inches below the surface. Whether the fire was local or general in extent cannot be ascertained. However, charcoal fragments were present from a depth of 55 inches all the way to the top of the deposit, which indicates not one but probably several fires. The low pollen count, from 55 to 27 inches (Figs. 5-6), and also the total absence of *Sphagnum* leaves and in their place black structureless microscopic remains seem to indicate that the fire was general in extent. It damaged not only the bog, but also much of the vegetation of the surrounding region; only a few trees were left to reseed the soil.

After the fire a burn subere consisting of the usual stages of annual and perennial herbs, shrubs, and trees was inaugurated in the area now freed of competition by the subclimax species (Clements, 1920). Fungi were abundant in the bog after the fire. This inference is based not only on the large percentage of spores present but also on observations made after a severe fire which occurred in 1931 in Mud Lake bog about twelve miles from Ann Arbor. Quantities of fungi, some of them undescribed species, appeared in this bog soon after the burn. The numerous fungi, including rusts, which continued to occur in the spore counts during this period (Fig. 5, 55-27 in.), may indicate the presence of rusts on the fireweeds, willows, and poplars, which are sometimes heavily infected with them.

The fire indicator, bracken fern, *Pteris aquilina*, probably formed extensive societies over the burn-scarred region. Among the plants which quickly invaded after the burn and became widespread because of their easily disseminated seeds were the fireweeds, *Epilobium* and *Erechtites*. Sometime later *Rubus idacus* var. *aculeatissimus* (?) and *R. allegheniensis* (?) became abundant. The former is now dominant in burnt-over beech-maple land in the northern part of the Southern Peninsula of Michigan.

The presence of alder, hazel, and birch in large numbers may account for the marked increase in the pollen of Betulaceae after the fire. It may be surmised that the fire indicators, paper birch, *Betula alba* var. *papyrifera*, and the American aspen, *Populus tremuloides*, came in after the burn, although no fossil evidence of these species was found.

Meanwhile, in this region now characterized by fire indicators the pollen counts suggest that the oaks and the conifers at first decreased and then remained stationary while the elm, beech, ash, maple, and birches increased in varying amounts. It is likely that during this period there were many ground fires that prolonged favorable conditions not only for the fire indicators, but also for the continuance of an oak-hickory subclimax (Weaver and Clements, 1929). The lessening amount of hickory and beech that is indicated by pollen throughout the period may have resulted from ground fires. Moreover, general observations both in Michigan and elsewhere have shown that these trees suffer severely from light ground fires that readily scar the base of the trees and leave them open to attack by fungi.

Finally, after a steady gain, maple, oak, and elm probably became dominants in their respective habitats (Figs. 5-6, 27 in.). The walnut, *Juglans*, was a recent invader in the woods. The oaks and hickories occupied dry hills and lighter soils. In still drier upland situations the white pine, *Pinus Strobus*, doubtless formed pure stands, and the scrub pine occupied well-leached sandy hills. Arbor vitae and hemlock were also present, and in the shrub layer grew the common elder, *Sambucus canadensis*, the red-berried elder, *S. racemosa*, and the black raspberry, *Rubus occidentalis*. The Virginia white-tailed deer, *Odocoileus virginianus* (Fig. 7), roamed through the woods.

There is some evidence that shortly after the maples and oaks became abundant in the forest (Fig. 5, 23 in.) another fire occurred, which, although not so severe as an earlier one, was more severe than the ground fires that swept through the locality at frequent intervals. Beech, together with members of the Betulaceae, appear to have been badly injured. This family decreased very suddenly but after the fire regained dominance. In the herbaceous layer were fireweeds and the ragweed *Ambrosia*.

It is likely that, instead of the normal succession of herbs, shrubs, and trees developing in this burn subseries as in the former one, there was formed an intricate pattern of dominants. Because of the root-sprouting habit of certain shrubs, as well as of birch and aspen, and because of the release of seeds from the cones of scrub pine and white pine, these were all able to begin development the first year about the time the herbs began to appear. Thus the



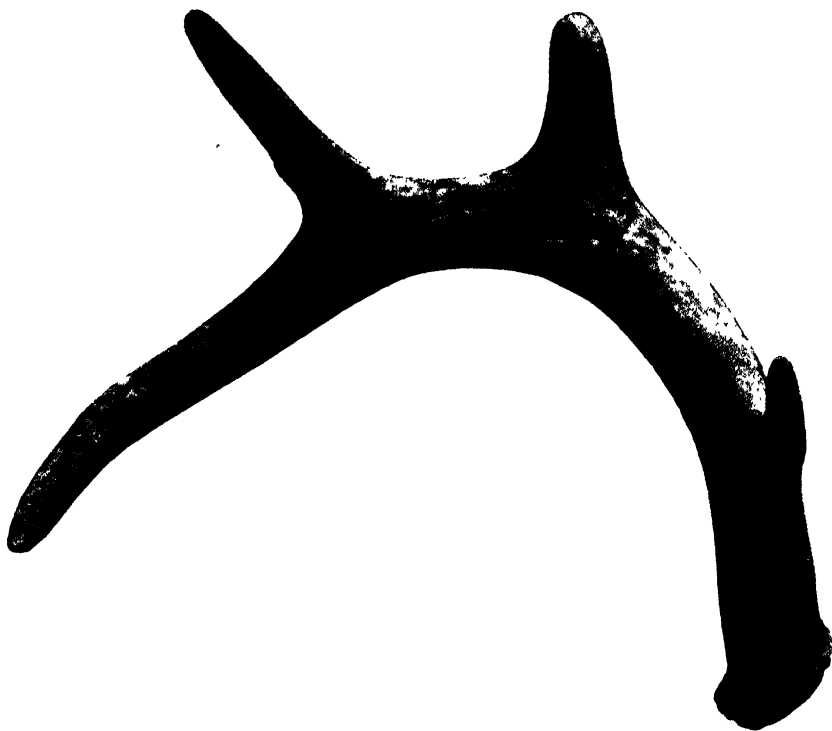


FIG. 7. Normally shed antler of Virginia white-tailed deer, *Odocoileus virginianus*, from Stratum 6d (see Fig. 3)

dominants of the herbs, shrubs, and trees probably appeared at almost the same time, but each dropped out in turn as competition with the next higher member became too great (Clements, 1920).

The final record of fossil vegetation from the Maumee terrace may be used to establish the plant communities in their natural habitats. In the drier uplands the forests were largely dominated by the oak-hickory association (including *Quercus alba*) with the undershrub *Corylus*, while on the heavy clay soils were representatives of the beech-maple climax forest. On the flood plains of the Huron River there occurred such trees as *Ulmus*, *Tilia*, *Fraxinus nigra*, *Juglans*, *Zanthoxylum americanum*, and *Prunus*. Along the river shores were growing thickets of willow, poplar, and alder, among which twined *Vitis vulpina*. There were brambles of black-

berries and red raspberries, and in open places dense stands of the common elder. In the herbaceous layer were composites, grasses, ferns, and mosses. The mosses were represented only by spores and a portion of a tiny leaf of *Amblystegium* sp. The reduced number of pollen grains and woods of coniferous origin seems to indicate that, except for hemlock and a few other relicts, the conifers had followed the zones of scrub and tundra as they migrated northward in the wake of the retreating ice.

The movement of climax zones northward is indicated by relict boreal species which still persist in this region "several hundred miles behind the zone to which they belong" (Clements, 1916). White pines may be found twenty-five miles north at Howell, Michigan. In the tamarack bogs of Washtenaw County *Larix laricina* is dominant in the bog-tree stage, with *Picea mariana* sometimes present. There are also a few cedar bogs in Washtenaw and Jackson counties in which *Thuja occidentalis* is a rare tree. These relicts now grow in bogs where they find protection and compensation against the new climate (Clements, 1934).

#### SUMMARY AND CONCLUSIONS

The alternating strata of tufa and peat in the Maumee terrace at Ann Arbor have recorded the successive waves of plant life as they moved northward in the wake of the Wisconsin glacier. They have preserved evidence of a gradual development of the vegetation from the early invaders, which were able to withstand extreme physical conditions, to the final mixed deciduous forest, which required favorable conditions.

Along with the progressive development of the vegetation there was doubtless a corresponding development of the soil, from the sterile till or gravel left by the glacier to the well-drained fertile soil capable of supporting a mixed deciduous forest (Shantz and Zon, 1924). Moreover, along with the development of the vegetation and soil there was a gradual amelioration of the climate which had its resultant effect upon plants and their habitats.

Alternating moist and dry periods were probably indirectly responsible for the production of the layers of tufa and peat respectively. The thick layer of peat (Fig. 3, Stratum 6a) may have been formed during a major dry cycle.

Although the development of the vegetation was inhibited by

fires, after which burn subseres were inaugurated, the course of the succession was resumed each time and finally resulted in a mixed deciduous forest.

1. The tufa-peat deposit at Ann Arbor, Michigan, was formed after the lowering of the level of the highest stage of glacial Lake Maumee.

2. According to the estimate of Dr. Frank Leverett, the oldest part of the deposit was formed about 30,000 years ago.

3. Fifty-five animals, mostly mollusks, and forty-four plants were identified from the deposit.

4. The same species of animals and plants which lived during the closing part of the Wisconsin glacier are present in some part of the state today.

5. The abundance of terrestrial shells and the layers of tufa indicate that much of the deposit was formed in seepage water.

6. The peat and tufa layers may be indirectly related to the amount of precipitation.

7. Willow, alder, birch, and spruce were probably the first trees in the region and may have entered in the order given. They were followed by the northern conifers.

8. The thickest peat layer may indicate a major dry cycle, during which fire-tolerant pines maintained dominance over the deciduous trees.

9. After deciduous trees gained dominance burn subseres were inaugurated by fires.

10. The final record gives a mixed deciduous forest with relicts of the northern coniferous forest.

11. Because of the shrinkage and final disappearance of the ice sheet, the climate appears to have changed from one as cold as that of northern Michigan to one similar to that of central Michigan today.

UNIVERSITY OF MICHIGAN

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## EXPLANATION OF PLATE I

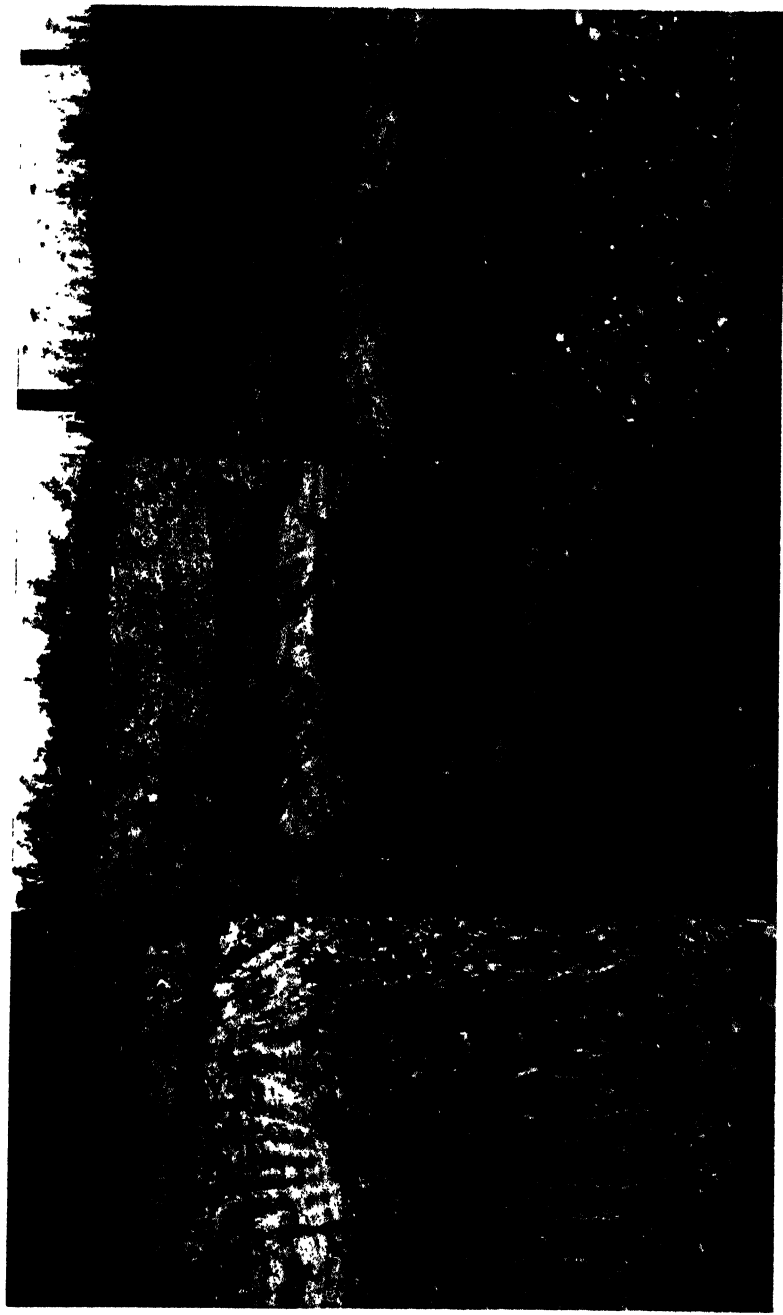
Tufa and peat in Maumee terrace bench exposed along the Plymouth Road,  
in freshly graded highway U.S.-12 (photograph by Professor H. H. Bartlett,  
1925)



## EXPLANATION OF PLATE II

Three views of the beveled roadside, showing the deposit of tufa interbedded with peat. The cut is roughly parallel to the irregular margin of the Maumee terrace. No regular bedding could be made out until a trench was cut at a right angle to the roadside (photographs by Professor H. H. Bartlett, 1925)





## EXPLANATION OF PLATE III

Vertical end wall of the beginning of the trench, showing the following strata:

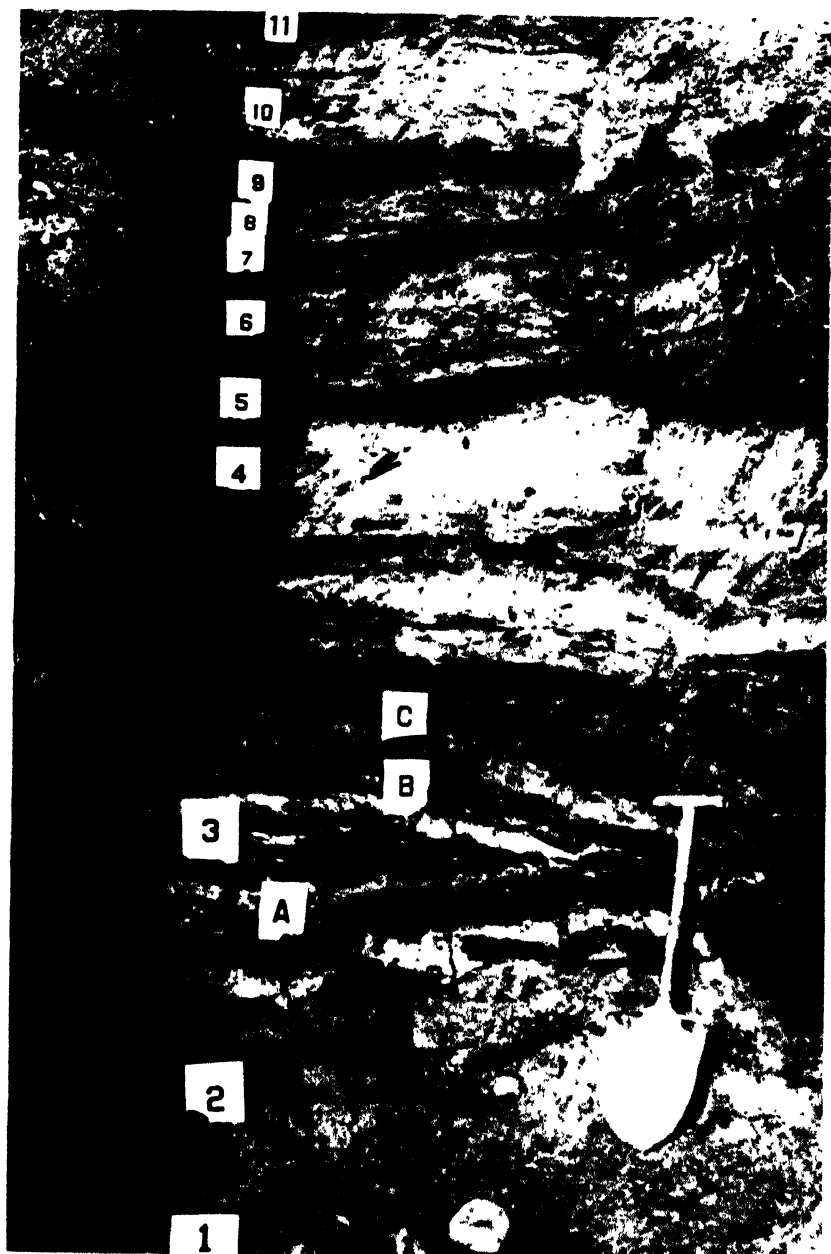
FIG. 1. Maumee blue plastic clay upon sandy boulder clay

FIG. 2. Yellow tufa

FIG. 3. Variegated peat (peat and tufa); wood at A, B, and C

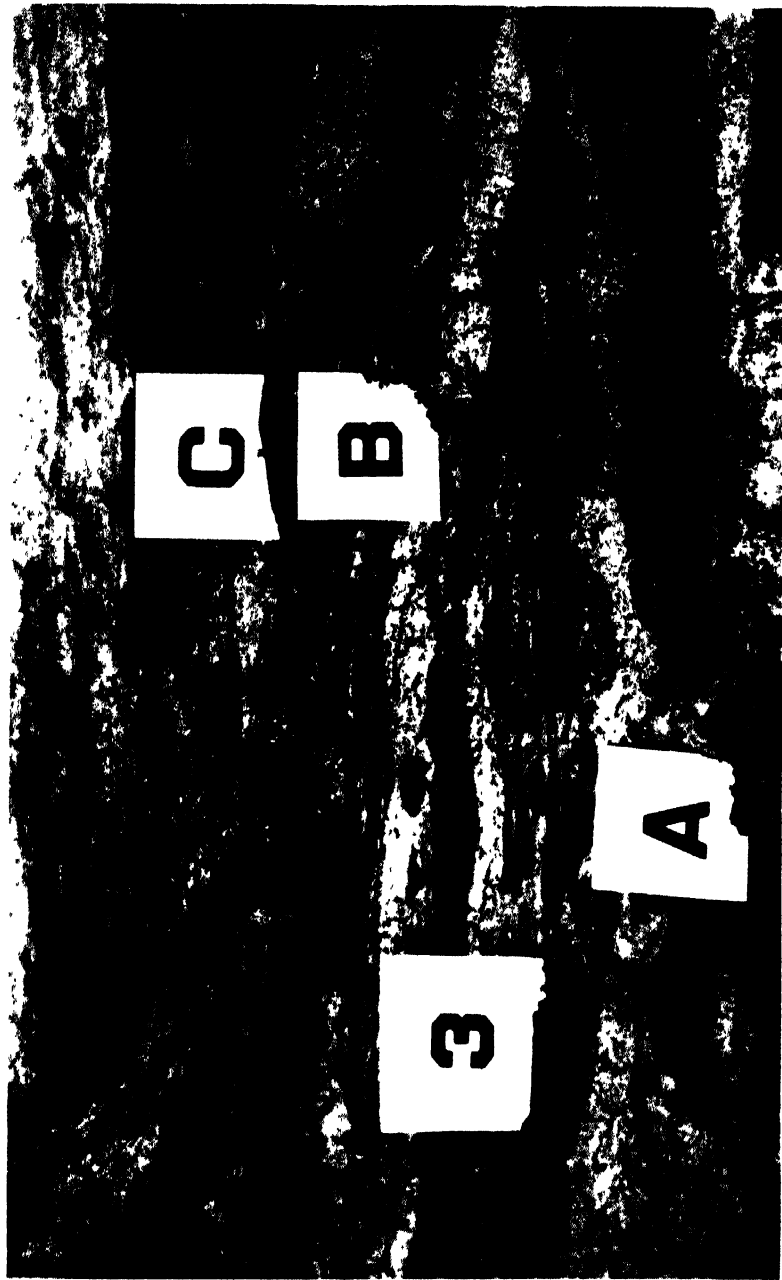
FIGS. 4-10. Tufa and peat in alternating layers

FIG. 11. Topsoil



## EXPLANATION OF PLATE IV

Enlargement of Stratum 3 of Plate III, showing fine stratification. Wood located at A, B, and C

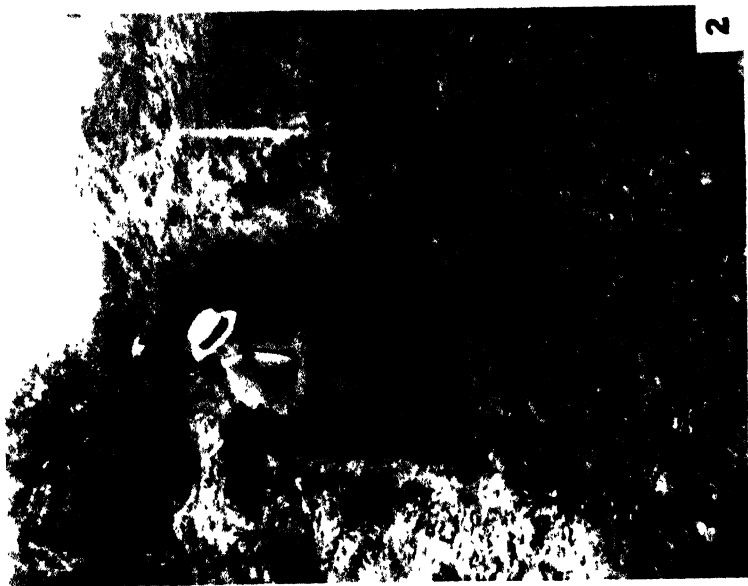


## EXPLANATION OF PLATE V

**FIG. 1.** Dr. Frank Leverett, the most distinguished American glacial geologist, determining the altitude of the Maumee deposit

**FIG. 2.** Trench extending into Maumee terrace from Plymouth Road. Dr. Leverett examining fossils

PLATE V



ANSE



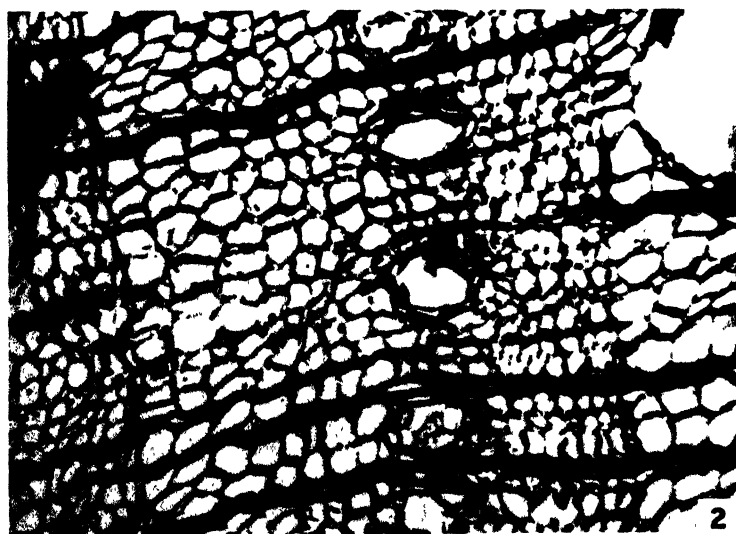
## EXPLANATION OF PLATE VI

Transverse sections of woods from the Maumee deposit. Their location is shown in Table II

FIG. 1. *Pinus Strobus* L.  $\times 150$

FIG. 2. *Larix laricina* (DuRoi) Koch.  $\times 150$



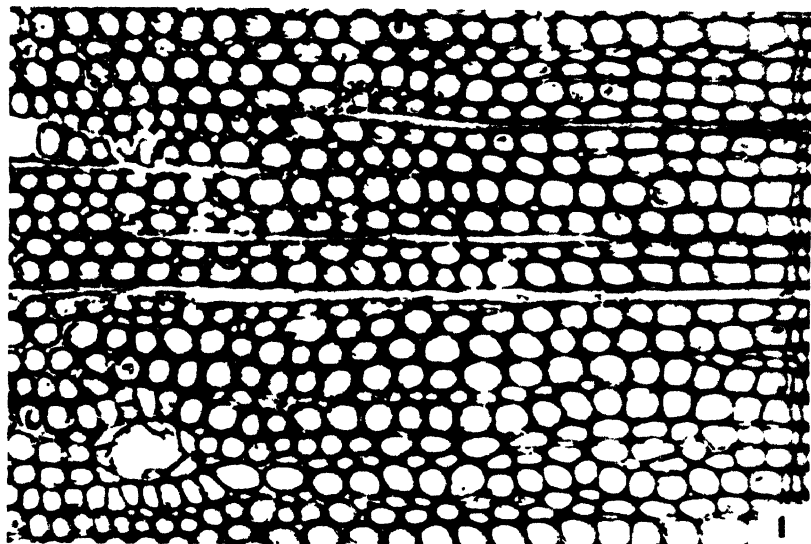


## EXPLANATION OF PLATE VII

Transverse sections of woods from the Maumee deposit. They were located in Stratum 3, Figure 3, and in other places (Table II)

FIG. 1. *Picea mariana* (Mill.) BSP.  $\times 150$

FIG. 2. *Abies balsamea* (L.) Mill.  $\times 150$



## EXPLANATION OF PLATE VIII

Seeds and achenes from Maumee deposit. Their location is shown in Table II.

FIG. 1. *Scirpus* sp. Achene.  $\times 6$

FIG. 2. *Carex retrorsa* Schwein. Achene.  $\times 4$

FIG. 3. *Rubus idaeus* var. *aculeatissimus* [C. A. Mey.] Regel & Tiling (?). Seed  $\times 6$

FIG. 4. *Rubus allegheniensis* Porter (?). Seed.  $\times 6$

FIG. 5. *Rubus occidentalis* L. (?) Seed.  $\times 6$

FIG. 6. *Sambucus racemosa* L. Seed.  $\times 4$

FIG. 7. *Sambucus canadensis* L. Seed.  $\times 4$

FIG. 8. *Vitis vulpina* L. Seed.  $\times 4$

FIG. 9. *Zanthoxylum americanum* Mill. Seed.  $\times 6$



1



2



3



4



5



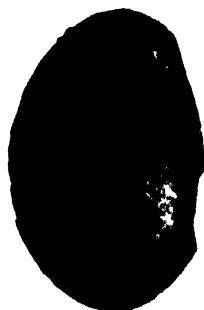
6



7



8



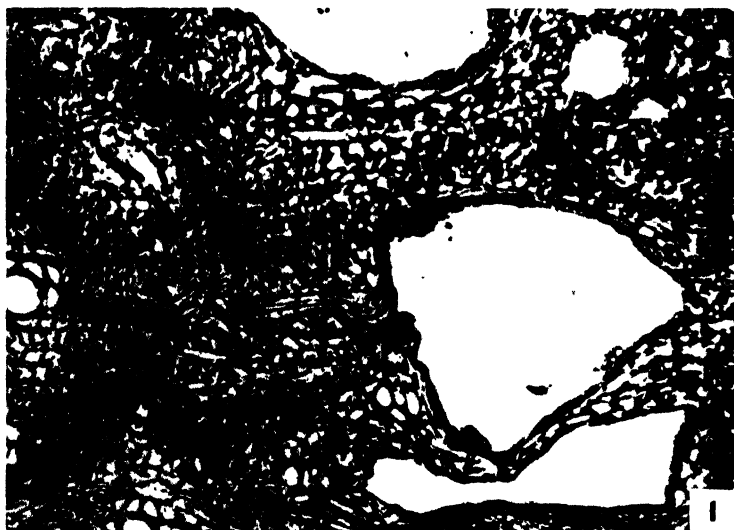
9

## EXPLANATION OF PLATE IX

Transverse sections of woods from the Maumee deposit. Their location is shown in Table II.

FIG. 1. *Fraxinus nigra* Marsh.  $\times 150$

FIG. 2. *Quercus alba* L.  $\times 80$







## SOME LICHENS FROM IDAHO

JOYCE HEDRICK

THE material upon which this report is based was collected in Idaho by Dr. Alexander H. Smith, botanist in the Herbarium of the University of Michigan, during the summers of 1935, 1939, and 1941. The collecting of lichens was incidental, and time was given to it only when it was not possible to secure other fungi.

Specimens were collected in the southwestern part of the state. In 1935 some were obtained from a petrified forest, south of Caldwell, and just across the state line from the town of Rockville, Oregon. In 1939 a few were found along Thorn Creek, near Boise. In 1939 and 1941 the collections were made in the region about Payette Lakes in the northwestern part of Valley County. Much material was taken from the rocks near Payette Lakes, on the trail to Boulder Lake, at an elevation of about 5,600–5,900 feet, around Louis Lake at 8,000 feet, and as far south as McCall. In 1941 specimens were also collected from the volcanic rocks near Craters of the Moon, at an altitude of about 5,000 feet.

So far as the writer has been able to ascertain, little work on lichens has been done within the State of Idaho. Many small collections have been made from time to time, and these have been reported in various publications, but the writer has seen no comprehensive study of lichens of the state. A number of species from Idaho are given in Fink's *Lichen Flora of the United States* (2). E. C. Berry (1) lists six species of the genus *Parmelia* from collections in the state, and Albert W. C. Herre (5) adds another species of the same genus in a recent paper.

Owing to the high altitudes and the time of collecting, numerous specimens were found to be immature. Much valuable information might be obtained if specimens could be taken from the same regions later in the summer or very early in the spring.

During the work for this study 276 specimens were identified. These are to be found in the Herbarium of the University of Michigan.

There are 51 species and 2 varieties in 16 genera, which represent 12 families. One variety, *Gyrophora decussata* var. *Darrowii* Frey, which was described from specimens collected in Nevada and California, appears to be frequent in the part of Idaho represented in this article.

## LIST OF SPECIES

- DERMATOCARPON AQUATICUM (Weis.) Zahlbr. — On rocks in cracks, Boulder Lake Trail, near McCall, 15723, July 27, 1941.
- URCEOLARIA SCRUPOSA (Schreb.) Ach. — On rocks, Payette Lakes, 16124, August 7, 1941.
- PELTIGERA CANINA (L.) Willd. — On soil, Boulder Lake Trail, near McCall, 15716, July 27, 1941.
- LECIDEA ATROBRUNNEA (Ram.) Schaer. — On petrified wood, across the state line from Rockville, Oregon, 1812, August 27, 1935; on rocks, Payette Lakes, 15676, 15692, 15695, 16102, August 10, 1939; 15677, 15701, 15702, July 20, 1941; 16086, 16088, 16092, 16094, 16096, 16097, 16100, 16101, 16108, 16110, 16112, 16113, 16118, 16120, 16129, 16153, August 7, 1941; Craters of the Moon, 15612, 15624, 15630, July 11, 1941; Louis Lake, near McCall, 15761, 15762, 15765, 15766, 15770, 15773, 15776, 15786, July 27, 1941.
- LECIDEA AURICULATA T. Fries. — On rocks, Payette Lakes, 16102, August 10, 1939; Louis Lake, near McCall, 15791, July 27, 1941.
- LECIDEA FUSCESCENS Sommerf. — On bark of trees, Payette Lakes, 16167, August 6, 1941.
- LECIDEA LAPICIDA Ach. — On rocks, Louis Lake, near McCall, 15782, July 27, 1941; Payette Lakes, 16128, August 7, 1941.
- LECIDEA PLATYCARPA Ach. — On petrified wood, across the state line from Rockville, Oregon, 1810, 1814, 1825, August 27, 1935; on rocks, Payette Lakes, 15688, 15689, July 20, 1941; Boulder Lake Trail, near McCall, 15735, 15736, 15737, July 27, 1941; Louis Lake, near McCall, 15769, 15774, July 27, 1941.
- PSORA GLOBIFERA Ach. — On soil in cracks between rocks, along Thorn Creek, near Boise, 1824, summer of 1939; Payette Lakes, 15673, 15675, July 20, 1941; 16085, August 7, 1941.
- RHIZOCARPON GEOGRAPHICUM (L.) Lam. & DC. — On rocks, Payette Lakes, 15682, 15691, 16102, 16114, 16126, August 8-10, 1939; 15677, July 20, 1941; 16092, 16100, August 7, 1941; Louis Lake,

near McCall, 15761, 15762, 15764, 15765, 15766, 15770, 15784, 15791, July 27, 1941.

*RHIZOCARPON GRANDE* (Floerke) Arn. — On rocks, Payette Lakes, 16089, 16103, 16151, August 9–10, 1939; 15681, 15683, 15685, 15694, July 20, 1941; 16091, 16107, 16109, 16111, 16121, 16122, 16144, August 7, 1941; Craters of the Moon, 15620, 15629, July 11, 1941; Louis Lake, near McCall, 15790, July 27, 1941.

*CLADONIA PYXIDATA* (L.) Hoffm. — On soil, Boulder Lake Trail, near McCall, 15729, July 27, 1941; Payette Lakes, 16060, 16061, 16134, August 6–7, 1941.

*GYROPHORA DECUSSATA* (Vill.) Zahlbr. — On rocks, Payette Lakes, 16151, August 9, 1939; Craters of the Moon, 15622, July 11, 1941.

*GYROPHORA DECUSSATA* var. *DARROWII* Frey. — On rocks, Payette Lakes, 15679, 15699, August 9–10, 1939; Craters of the Moon, 15608, 15609, 15614, 15618, 15619, 15626, 15629, 15633, 15635, 15636, 15650, 15657, July 11, 1941.

*GYROPHORA EROSA* (Weberi) Ach. — On rocks, Boulder Lake Trail, near McCall, 15724, 15732, July 27, 1941.

*GYROPHORA HYPERBOREA* Ach. — On rocks, Payette Lakes, 15705, 15706, 15709, July 20, 1941; 16152, August 7, 1941; Boulder Lake Trail, near McCall, 15724a, July 27, 1941; East Fork of Lake Fork, 15668, July 18, 1941; Craters of the Moon, 15600, 15617, July 11, 1941.

*GYROPHORA MÜHLENBERGII* Ach. — On rocks, Payette Lakes, 15707, July 20, 1941.

*GYROPHORA PHAEA* (Tuck.) Nyl. — On rocks, Payette Lakes, 16103, August 10, 1939; 15694a, July 20, 1941; 16136, August 7, 1941.

*GYROPHORA PROBOSCIDEA* (L.) Ach. — On rocks, Payette Lakes, 15711, 16095, 16098, 16115, 16130, 16146, 16152, 16154, 16155, August 8, 1939.

*GYROPHORA RUGIFERA* (Nyl.) T. Fries. — On rocks, Craters of the Moon, 15623, July 11, 1941.

*GYROPHORA TORREFACTA* (Leightf.) Cromb. — On rocks, Craters of the Moon, 15638, July 11, 1941.

*GYROPHORA VELLEA* (L.) Ach. — On rocks, along Thorn Creek, near Boise, 1822, summer of 1939; Payette Lakes, 15674, July 20, 1941; 16131, 16132, 16133, August 7, 1941.

*LECANORA ALPINA* Sommerf. — On rocks, Louis Lake, near McCall, 15784, July 27, 1941.

- LECANORA ATRA (Huds.) Ach. — On rocks, Payette Lakes, 16126, August 8, 1939.
- LECANORA CINEREORUFESCENS (Ach.) Nyl. — On rocks, Payette Lakes, 15692, August 10, 1939.
- LECANORA MELANOPHTHALMA (Lam. & DC) Ramond. — On petrified wood, across the state line from Rockville, Oregon, 1806, 1807, 1811, 1816, August 27, 1935; on rocks, Craters of the Moon, 15614, 15619, 15627, 15629, 15633, 15636, 15643, 15648, 15654, 15656, July 11, 1941.
- LECANORA MURALIS (Schreb.) Rabh. — On petrified wood, across the state line from Rockville, Oregon, 1801, 1808, August 27, 1935.
- LECANORA OREGANA Tuck. — On rocks, Payette Lakes, 16095, 16098, 16125, August 9, 1939; 16084, 16087, August 7, 1941; Craters of the Moon, 15615, 15635, July 11, 1941.
- LECANORA POLYTROPA (Ehrh.) Rabh. — On rocks, Payette Lakes, 16116, August 10, 1939.
- LECANORA RUBINA (Vill.) Ach. — On petrified wood, across the state line from Rockville, Oregon, 1813, 1816, 1818, August 27, 1935; on rocks, Craters of the Moon, 15641a, 15655a, 15658, July 11, 1941; Payette Lakes, 16081, August 7, 1941.
- LECANORA RUPICOLA (L.) Zahlbr. — On rocks, Payette Lakes, 15682, 15690, August 10, 1939.
- LECANORA SUBFUSCA (L.) Ach. — On rocks, Payette Lakes, 15678, 16124, August 10, 1939; 15680, 15687, 15700, July 20, 1941; Boulder Lake Trail, near McCall, 15734, July 27, 1941; Louis Lake, near McCall, 15762, 15770, 15770a, 15780, 15783, 15788, 15792, July 27, 1941.
- LECANORA SUBFUSCA var. COILLOCARPA Ach. — On bark of trees, Boulder Lake Trail, near McCall, 15726, July 27, 1941; Payette Lakes, 16067a, 16071, 16079, August 6-7, 1941.
- PARMELIA CONSPERSA (Ehrh.) Ach. — On pebbles, across the state line from Rockville, Oregon, 1820, August 27, 1935.
- PARMELIA MOLLIUSCULA Ach. — On soil, across the state line from Rockville, Oregon, 1815, August 27, 1935.
- PARMELIA OLIVACEA (L.) Ach. — On trees, Payette Lakes, 16137, August 7, 1941.
- PARMELIA PHYSODES (L.) Ach. — On trees, Payette Lakes, 16068, 16070, 16072, 16074, 16076, 16076a, 16078, 16140, August 7, 1941.

- PARMELIA SOREDIATA* (Ach.) Rohling. — On rocks, Payette Lakes, 15686, July 20, 1941.
- PARMELIA STYGIA* (L.) Ach. — On rocks, Payette Lakes, 15704, August 8, 1939.
- CETRARIA CALIFORNICA* Tuck. — On trees, Payette Lakes, 16072, 16135, 16139, 16140, August 7, 1941.
- CETRARIA JUNIPERINA* (L.) Ach. — On branches of trees, along Thorn Creek, near Boise, 1821, summer of 1939.
- CETRARIA PLATYPHYLLA* Tuck. — On trees, Payette Lakes, 16072, 16074, 16076, 16076a, 16080, August 7, 1941.
- CETRARIA TRISTIS* (Web.) E. Fries. — On rocks, Payette Lakes, 16151, 16154, 16155, 15684, 15693, 15712, August 9, 1939.
- EVERNIA VULPINA* (L.) Ach. — On rocks, Payette Lakes, 16082, August 8, 1939; on branches of trees, Payette Lakes, 16072, 16073, 16074, 16076, 16076a, 16076b, 16135, 16140, August 7, 1941; South Fork of Lake Fork, 15667, 15710, July 19–20, 1941; Louis Lake, near McCall, 15763, July 27, 1941.
- ALECTORIA JUBATA* (L.) Ach. — On trees, Payette Lakes, 16066, 16074, 16075, 16076, 16076a, 16076b, 16077, August 7, 1941.
- ALECTORIA OREGANA* Nyl. — On trees, Payette Lakes, 16072, 16074, 16075a, 16076, 16076a, 16135, 16139, 16140, August 7, 1941.
- CALOPLACA AURANTIACA* (Leightf.) T. Fries. — On trees, Payette Lakes, 15708, July 20, 1941; 16057, 16059, 16062, August 6, 1941.
- CALOPLACA ELEGANS* (Link.) T. Fries. — On petrified wood, across the state line from Rockville, Oregon, 1800, 1823, 1826, August 27, 1935; on rocks, Payette Lakes, 15698, 15703, 16125, August 8, 1939; Craters of the Moon, 15636, 15637, 15642, 15655, 15660, July 11, 1941.
- CALOPLACA FERRUGINEA* (Huds.) T. Fries. — On rocks, Payette Lakes, 16056, August 9, 1939; 16092, August 7, 1941.
- CALOPLACA MURORUM* (Hoffm.) T. Fries. — On petrified wood, across the state line from Rockville, Oregon, 1829, August 27, 1935.
- BUELLIA PARASEMA* (Ach.) De Not. — On old wood, Payette Lakes, 16058, August 6, 1941.
- PHYSICIA PULVERULENTA* (Schreb.) Nyl. — On soil, Payette Lakes, 16142, August 10, 1939; 16138, August 7, 1941.
- PHYSICIA SETOSA* (Ach.) Nyl. — On soil over rocks, Boulder Lake Trail, near McCall, 15730, July 27, 1941.

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4. ——— 1936. Die geographische Verbreitung der Umbilicariaceen und einiger alpiner Flechten. *Ibid.*, Band 46.
5. HERRE, ALBERT W. C. T. 1946. The *Parmelias* of California. *Contributions from the Dudley Herbarium, Stanford University, California*, 3 (10) : 313-350.

# SOME STUDIES IN THE GENUS *HELVELLA* \*

BESSIE B. KANOUSE

**I**N CONNECTION with research on the genus *Helvella*, I have accumulated some data that have a bearing on the taxonomic status of the genus and of some of the species which comprise it. The results are presented in this paper.

Even though the family *Helvellaceae* is an old one and supposedly well studied, considerable difficulty is still encountered in making identifications in this group. Many genera and subgenera have been proposed, and more than 170 specific and varietal names have been published for the genus *Helvella* alone. The synonymy for certain species is considerable. In the old literature, particularly, the descriptions were based upon inadequate observations, and emphasis was frequently placed on the macroscopic characters. These become important and reliable when they can be correlated with morphological characters of diagnostic significance, such as structure and spore size. In this genus, especially, the macroscopic characters must be considered carefully and the differences evaluated with caution, since the amount of variation in size, color, and shape of fruit bodies is often great within a species. The illustrations accompanying the older reports tend to emphasize these variations, and undue significance has been attached to them. In the more recent literature there appear to be misinterpretations, so that the present-day taxonomy of the genus, together with the nomenclatorial aspects, is a real problem.

The present study was undertaken primarily to ascertain the usefulness of a chemical test in making identifications of fungi in the *Helvellaceae*. Smith and Singer (31), in connection with their studies on the genus *Cystoderma*, found that a 2.5 per cent solution of KOH produced color reactions in the cells of the cuticle ranging through negative (hyaline), olivaceous or strongly olivaceous, to cinnamon-russet. They were able to separate groups of species by means of these reactions, and they place considerable weight upon the results of this technique in species of *Cystoderma*.

\* Papers from the Herbarium of the University of Michigan.

The use of iodine solution as a stain in connection with Discomycetes is standard practice. Rehm (28) employed it regularly. Seaver (30), however, made no reference to it and apparently considered it to be of no value. Lagarde (22) reported upon the use of stains in connection with his studies of several species of *Helvella*, but KOH was not among those used by him, and he drew no taxonomic conclusions from the stains he did use. In the study of lichens the use of stains is becoming more generally accepted. Nannfeldt (24) suggested the desirability of finding some new chemical test that would aid in identifying Discomycetes.

The observations reported in this paper were made on freehand sections of both fresh and dry herbarium material mounted in 2.5 per cent solution of KOH. The following species were examined: *Helvella albella* (Quél.) Boud. (1 coll.); *H. albipes* Fuck. (2 coll.); *H. atra* Fr. (13 coll.); *H. californica* Phill. (13 coll.); *H. caroliniana* Bosc. ex Fr. (7 coll.); *H. crispa* Fr. (17 coll.); *H. elastica* Bull. ex Fr. (43 coll.); *H. esculenta* Pers. ex Fr. (16 coll.); *H. gigas* Krombh. (5 coll.); *H. infula* Schaeff. ex Fr. (42 coll.); *H. lacunosa* Afz. ex Fr. (53 coll.); *H. monachella* Scop. ex Fr. (1 coll., Rehm: Ascomyceten no. 1561); *H. pezizoides* Afz. ex Fr. (1 coll., Rehm: Ascomyceten no. 1352); *H. pezizoides* var. *minor* (2 coll.); *H. pulla* Holmsk. ex Fr. (1 coll., Rehm: Ascomyceten no. 1251); and *H. sphaerospora* Pk. (4 coll.).

Before taking up the effects of the KOH solution, it is desirable to consider the structure of the fruiting head and to discuss briefly the nature of the hymenial and subhymenial layers. The reader is referred to Corner (10) and to McCubbin (23), who have published upon the morphology of the ascocarps in certain species of the genus *Helvella*. I have examined more species of *Helvella* than did these authors, and my observations confirm their findings and extend the knowledge by the study of additional species.

The tissue of the fruiting head is composed of three layers: the hymenium, the hypothecium or medulla, and the exciple or cortex. The hymenium consists of the asci and the paraphyses. The asci are operculate, and the spores fall into several distinct groups: narrowly oblong, containing two oil drops; ellipsoid, containing two oil drops; ellipsoid, with one large oil drop; large ellipsoid, smooth, with one oil drop; large, ellipsoid, rough, with one oil drop; and spherical smooth. The paraphyses exhibit no outstanding difference



in the several species. They vary somewhat, but in general are filiform, clavate-tipped, and branched, frequently at a point below the middle. Septa are commonly present. Coloring matter may give the paraphyses a slight yellowish cast, and in two species, *H. atra* and *H. lacunosa* (which have dark-colored pilei), they are brown. The paraphyses are abundant in all species. They reach the tips of the asci and sometimes project slightly beyond, but never form an epithecium.

The hypothecium is the hyphal layer directly beneath the hymenium. It soon loses its hyphal nature and becomes pseudoparenchymatic, presenting the appearance of a layer of small, compact cells. This layer is usually less thick than the hymenium or the exciple and is gray hyaline.

Below the hypothecium is the excipular layer, or cortex. Three types of excipular development were observed. A palisade layer, or a modification of such a layer, is usually found. In one group of species the under surface consists of a regular, even palisade made up of large irregular hyaline cells that are formed into chains pressed closely together. The surface is occasionally broken by longer, projecting chains, but is otherwise comparatively even. The species in which this condition was observed are: *H. albella*, *H. albipes*, *H. lacunosa*, *H. monachella*, *H. pezizoides*, and *H. pulla*. Another group is represented by two species, *H. crispa* and *H. elastica*, in which the excipular layer showed extreme irregularity. The chains were grouped into pyramidal mounds, and the variation in shape and size of these chains, together with the more frequent occurrence of stray chains, produced a decidedly irregular surface. The amount of irregularity was not sufficient to form a distinct pubescence in any species except *H. pezizoides*. Lack of material for study makes it impossible to say whether or not this is a constant character for this species; it is so reported in descriptions of the species. In the third group both the palisade layer and the pyramidal mounds are lacking altogether. There is instead a loose unorganized arrangement of cells that are somewhat larger than the cells found in the hypothecium. They retain so much of the hyphal nature that it must be regarded as prosenchymatic. The outermost layer is irregularly cellular. The species in this group are: *H. californica*, *H. caroliniana*, *H. esculenta*, *H. gigas*, *H. infula*, and *H. sphaerospora*.

The color found in the fruiting head occurs principally in the

paraphyses. A small amount is sometimes seen in the excipular cells and usually gives them a sordid yellowish tint. The paraphyses of *H. lacunosa* and *H. atra* have normally a decidedly brownish color. Iodine solution does not produce in them a blue coloration.

KOH solution produces four types of color reaction in the various species. In one group the paraphyses turn bright yellow, in another, reddish brown to cinnabar-brown, in another, dark brown, and in the fourth they range in color from hyaline to sordid yellowish to pale fuscous. The bright yellow appears in *H. californica*, *H. caroliniana*, *H. gigas*, and *H. sphaerospora*; the red, in *H. esculenta* and *H. infula*. The dark brown is merely an intensification of the natural brown of *H. atra* and *H. lacunosa*, and the sordid yellowish to practically negative reaction, in which at least the tips of the paraphyses remain hyaline, characterizes the remainder of the species examined, of which *H. albipes*, *H. crispa*, and *H. elastica* are typical. The groups of species thus blocked out by means of KOH correspond roughly to groupings made on the basis of morphological data. The naturally dark-colored species, *H. atra* and *H. lacunosa*, react alike, as do the two related species *H. esculenta* and *H. infula*. In addition, *H. californica*, *H. caroliniana*, *H. gigas*, and *H. sphaerospora*, which have somewhat similar fruit bodies and an excipular development that is comparable, all show the yellow coloration. Apparently these chemically induced color distinctions conform more or less to the natural groupings.

Information gathered in the investigations just discussed has a direct bearing upon the interpretation of some of the genera in the Helvellaceae and also upon some of the species concepts. It is unnecessary to give here the complete historical account of the Helvellaceae. Many taxonomic arrangements have been put forward that involve the establishment of new genera and subgenera. The reader is referred for such material to the following sources: Anderson and Ickis (1); Banhegyi (2); Bataille (3); Beauseigneur (4); Bigeard and Guillemin (5); Boudier (7); Cooke (9); Fries (11,12); Fuckel (13); Gillet (14); Grelet (15); Hone (16); Imai (17, 18); Karsten (19); Kavina (20); Krombholtz (21); Nannfeldt (25); Phillips (26); Quélet (27); Seaver (30); and Velenovský (32).

Not all the described species have been seen by me — Seaver (30) lists only fourteen species from North America — but enough of them have been examined to enable me to vouchsafe the opinion

that the phylogeny of the group is more clearly understood and represents the natural order more accurately when the genus *Helvella* is considered in a broad sense. Recognizable variations exist within species, and some of the plants exhibiting them have been designated as varieties. This gradual flow of characteristics within a species, as well as between species, seems to demonstrate that a close unity exists in this group of fungi. When such a gradation of morphology can be traced, the necessity of creating many genera appears questionable. To break up the continuity of a natural progression by sharp generic barriers only tends toward confusion. The differences may be viewed as a natural progression, rather than as sharp divisions. *Gyromitra*, *Physomitra*, *Leptopodia*, *Neogyromitra*, and *Globopilus* are examples of genera that do not seem to be required for an accurate interpretation of this group. Neither does it appear that the creation of subgenera facilitates an understanding of the taxonomy.

One of the classic arguments involves the validity of the genus *Gyromitra*. Some consideration is given that question here since it concerns the position of *H. esculenta*, and also that of *H. sphaerospora*, *H. caroliniana*, and *H. gigas*, which have been placed in the genus. *Gyromitra* was established by Fries (12), on the basis of the gyrose cap, to take care of *H. esculenta*. This disposition separated *H. esculenta* and *H. infula*, which are shown in the present paper to be closely related, but distinct, species. The gyrose condition alone affords insufficient ground on which to maintain a genus, especially when it is realized that convolution is sometimes present in species having caps that are normally smooth, or at most wrinkled. The inclusion of *H. californica*, *H. sphaerospora*, and *H. gigas* is forced, since in these species the caps are not truly gyrose. Furthermore, the KOH reaction in these three is in sharp contrast to that found in *H. esculenta*. The evidence for and against the acceptance of *Gyromitra* is set forth by Seaver (29), by Anderson and Ickis (1), and by others. It suffices to say that I prefer to use the genus *Helvella* in the broad sense, as defined by Seaver (30).

The question whether or not the two species *H. infula* and *H. esculenta* are synonymous is also of long standing. From a careful study of both fresh and herbarium material I am convinced that the two are undoubtedly distinct. A fine collection of fresh fruit bodies was examined. It consisted of more than one hundred caps found

growing under *Populus grandidentata* and *Abies balsamifera* at Lupton, Michigan, May 2, 1946. They were collected by A. H. Smith (no. 21388). The dried specimens examined came from New Hampshire, Michigan, Montana, Oregon, Washington, Canada, and Sweden. These collections, too, had been made in the spring, and all the specimens had been found growing under conifers. These are two circumstances that contrast sharply with the conditions characteristic of *H. infula*, which is collected in summer and early fall in localities where only deciduous trees are present. In fact, the fruit bodies of this species are often found growing directly upon decayed wood of deciduous trees. In addition to these differences in season of growth and in habitat, there is a marked difference in the shape and stature of the fruit bodies in the two species. *H. infula* tends to be tall and slender, with a saddle-shaped cap. *H. esculenta* is a stouter plant, with a thicker stipe and a decidedly gyrose cap. The colors differ, too, for *H. infula* is usually some shade of tan or light brown, whereas the caps of *H. esculenta*, when fresh, range from "cinnamon-buff" (R.)<sup>1</sup> through "bay" to "chocolate," "Mikado brown," and "Hessian brown," the stipes being "buff pink" to "vinaceous tawny." But the principal difference is in spore shape and spore size. Freshly shed spores of *H. esculenta* measure  $24-28 \times 12-16 \mu$  and are decidedly ellipsoid. They contain two bright oil drops, one at each extremity of the spore. On germination the oil drops break down, and when the germ tube is  $50 \mu$  or less long all trace of globules is gone. The spores of this species revived in KOH were similarly ellipsoid, and were likewise consistently different in shape from those in *H. infula*, but they were slightly smaller than the spores from the fresh fruit bodies. The spores in *H. infula* are narrowly oblong and measure only  $16-18 \times 7-8 \mu$ . The forty-two collections of *H. infula* examined represent a wide distribution in the United States.

There is another confusing situation, involving *H. gigas* and *H. caroliniana*. Krombholtz (21) described and illustrated *H. gigas* as having smooth spores, but Seaver (29) put it in synonymy with *H. caroliniana*, which is a rough-spored species, and Boudier (6) made a similar error in illustrating *H. gigas* with rough spores. Bresadola (8) gives the correct interpretation of this species. Nann-

<sup>1</sup> Color terms quoted are from R. Ridgway, *Color Standards and Color Nomenclature*, 1912.

feldt (24) and Imai (17) concluded that *H. gigas* Krombh. does not occur in the United States. The Herbarium of the University of Michigan has collections of both these species; those of *H. gigas* were made in Idaho and Michigan, and those of *H. caroliniana*, in Illinois, Michigan, Ohio, and Tennessee. The spores of these collections of *H. gigas* measure  $30-35(40) \times 11-12(14) \mu$  and are smooth. The spores of the Michigan Herbarium collections of *H. caroliniana* measure  $26-34 \times 14-16 \mu$ , are sometimes apiculate, and are decidedly roughened by warty protuberances. The species is easily recognized by these rough spores.

Another question is raised concerning the two species *H. caroliniana* and *H. underwoodia* Seaver. The descriptions of the two are nearly identical. Seaver (30) separates them upon the assumption that the spores of *H. caroliniana* are strongly apiculate and that those of *H. underwoodia* are not. Collections of *H. caroliniana* spores have been examined, and both apiculate and nonapiculate spores have been found in the same fruit body. It is evident, therefore, that *H. underwoodia* becomes a synonym of *H. caroliniana*.

UNIVERSITY OF MICHIGAN

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# THE APPLICATION OF ZALENSKI'S LAW TO CERTAIN SUBMERGED PLANTS \*

MARION I. LEHNER

THE measurements and observations of leaves of upright terrestrial plants made by V. Zalenski and published in Russian in *Kiev Politekhnikheskii Institut Izvēstiia*, 4:1-203, in 1904, as reported in Maximov (6), have established the general rule that "the anatomical structure of the individual leaves of one and the same shoot is a function of their distance from the root system." Maximov (6) states: "This may justly be called Zalenski's law." Zalenski (*vide* 6 and 7) found that upright terrestrial plants have a tendency to show a more xeromorphic structure in the upper leaves than in the lower ones. Among the conditions he observed were a decrease in the size of vein islets, epidermal cells, and guard cells, and a greater frequency of stomates per unit of surface in the upper leaves.

Since it is accepted as a fact that the ancestors of flowering aquatic plants were terrestrial plants and since Zalenski and others (2, 6, 7) worked on upright terrestrial species which were subjected to the increasing drying effects of the atmosphere, certain long-stemmed submerged species of *Potamogeton* were chosen for study because they live under conditions of greatly reduced "transpiration." The purpose of this study was to see whether the tendency observed by Zalenski can be found in submerged aquatics also. He (*vide* 6) and Yapp (8) believe the fundamental reason for this xeromorphy of upper leaves may be the reduction in the amount of water available because of interception by lower leaves. Zalenski's findings have been confirmed by the works of Yapp (6), Heuser (*vide* 6), Rippel (*vide* 6), Miller (7), and others.

\* The investigations upon which this paper is based were conducted during July and August of 1941 at the Biological Station of the University of Michigan at Douglas Lake, Cheboygan County, Michigan.

The author acknowledges her indebtedness to Dr. Frank C. Gates and Dr. Carl D. La Rue for suggesting the problem and for assistance in its completion.

## METHODS

The stems of *Potamogeton richardsonii* (Benn.) Rydb. and *P. praelongus* Wulf. were found to be the longest of the long-leaved species growing in Douglas Lake. Fifty-six plants were collected

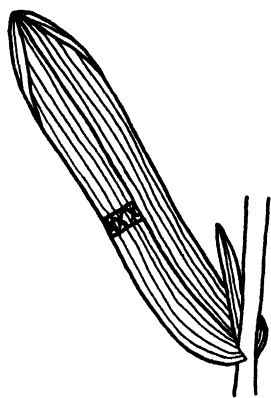


FIG. 1. *Potamogeton praelongus*, a leaf showing method of sampling

for study from water about twenty feet deep just beyond the dropoff on the southeastern shore of the lake. Since it was difficult to obtain specimens with roots, measurements were begun at the apex. The first mature leaf and the lowest leaf were selected, together with intermediate leaves at distances approximately one meter apart. Distances between these leaves were measured. A section about one centimeter square was cut from the median portion of each leaf (Fig. 1). This was mounted on a slide in a drop of lactic acid and placed in an oven at 50° C. for twenty-four to forty-eight hours, or until it was cleared. Measurements of lower epidermal cells were made by use of the

ocular micrometer at a magnification of 440 $\times$ . Ten cells were measured in each of three locations — at the margin and at the intermediate and central positions on the leaf (XXX in Fig. 1). These leaves were then classified into one-meter groups, starting at the tip. Measurements of ten vein islets were made with a Spencer projectoscope at a magnification of 12.5 $\times$ . The cells were found to be somewhat rectangular, and so measurements of length and width were taken along lines intersecting at right angles in the center (Fig. 2). Photomicrographs of typical cells and of typical vein islets are illustrated in the figures of Plate I.

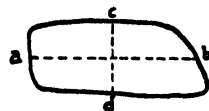


FIG. 2. Typical central epidermal cell, showing location of measurements. *a-b*, width of leaf; *c-d*, length of leaf

The complete data, which are much too lengthy to be included in this paper, have been filed in the library of the Biological Station at Douglas Lake and are available for study. The form used to record the data is shown in Table I. A summary of the total number of measurements taken is shown in Table II.



TABLE I

EXAMPLE OF THE METHOD USED TO RECORD THE MEASUREMENTS  
TAKEN ON EACH LEAF

*Potamogeton praelongus*, specimen 18, leaf 20.

Distance between nodes	Epidermal cells (ocular units*)						Vein islets †	
	Marginal		Intermediate		Central			
	Length ‡	Width	Length	Width	Length	Width	Length	Width
71 cm.	11.5	3.5	5.0	11.5	4.5	8.0	38.0	13.0
	7.5	4.0	3.5	6.0	4.0	9.0	43.0	7.0
	10.0	3.5	2.5	5.5	3.5	9.0	69.0	19.0
	13.0	4.5	4.0	11.5	3.5	8.0	56.0	20.0
	11.0	3.5	3.5	11.5	3.5	9.5	4.0	21.0
	11.0	4.0	3.5	11.5	4.5	8.0	45.0	22.5
	11.0	3.5	3.5	10.5	3.5	9.0	5.0	17.0
	7.0	4.5	4.5	5.0	3.5	9.5	118.5	17.0
	9.0	4.0	2.5	5.5	4.0	9.5	63.0	16.0
	13.0	4.0	5.0	11.5	3.0	9.0	45.0	14.0
Average	10.4	3.9	3.75	9.0	3.7	8.85	55.2	17.6

\* Ocular unit = 3.27 microns. Magnification 440×.

† 1 mm. projected = 12.5 mm. on screen.

‡ Measurements made with reference to shape of leaf, "length" being parallel to length of leaf and "width" to width of leaf.

The probable error was computed by methods and tables taken from the *Handbook of Chemistry and Physics* (5), which states that "the probable error of a series of  $n$  measurements  $a_1, a_2, a_3, \dots, a_n$ , the mean of which is  $m$ ," can be expressed by the following approximate equations, which are convenient forms of computation:

$$\text{Probable error of the series is } 0.8453 \frac{\sum d}{\sqrt{n(n-1)}}.$$

$$\text{Probable error of the mean is } 0.8453 \frac{\sum d}{n\sqrt{n-1}}.$$

The symbol  $\sum d$  represents the arithmetical sum of the deviation from the mean.

If three times the probable error is less than the difference between the mean of the first group and that of the second group, the figures may be said to show a significant difference. Measurements

TABLE II

A SUMMARY OF THE NUMBER OF MEASUREMENTS TAKEN

Distances from tip	Cells measured						Vein islets measured	
	<i>P. richardsonii</i>			<i>P. praelongus</i>			<i>P. richardsonii</i>	<i>P. praelongus</i>
	Marginal	Intermediate	Central	Marginal	Intermediate	Central		
Less than 1 meter	420	420	420	340	340	340	420	340
1-2	360	360	360	270	280	280	360	280
2-3	410	420	420	70	70	70	420	70
3-4	60	60	60	*	*	*	60	*
Total per species	3,770			2,060			1,260	690
Grand total	5,830						1,950	

\* No specimens were longer than three meters.

of the areas of epidermal cells and of the vein islets and the probable errors of each are given in Table III.

A comparison of the measurements of the areas of the cells and of the vein islets can best be made by determining the probable error of the differences, which can be computed by use of the formula

$$V = \frac{D}{\sqrt{(p.e.m.)^2} \sqrt{(p.e.M.)^2}},$$

in which  $V$  is the value of the difference and  $D$  is the difference between the two means  $m$  and  $M$ . If  $V$  is three or less, the difference between the two means is probably not significant. By examination of Table III it will be seen that only two of nine measurements of areas of cells and two of three measurements of areas of vein islets of *Potamogeton richardsonii* are significant, and four of six cells and one of two vein islets of *P. praelongus* are significant.

TABLE III

A SUMMARY OF AREAS TAKEN FROM AVERAGES OF MEASUREMENTS OF  
5,830 CELLS AND 1,950 VEIN ISLETS

Probable error of the mean and differences.

Measurements of cells are in microns and vein islets in millimeters projected.

Distances from tip		Epidermal cells			Vein islets
		Marginal	Intermediate	Central	
<i>Potamogeton richardsonii</i>					
Less than 1 meter (42 specimens)	Mean	163.0 ± 3.06	69.3 ± 1.78	82.3 ± 2.72	93.3 ± 10.10
1-2 (36 specimens)	Mean	201.0 ± 4.00	85.4 ± 2.11	79.4 ± 1.92	32.9 ± 1.17
	Diff.*	38.3 ± 7.62	16.1 ± 0.15	2.91 ± 0.008	60.4 ± 0.61
2-3 (42 specimens)	Mean	216.0 ± 5.96	89.6 ± 1.81	104.0 ± 2.36	45.5 ± 1.31
	Diff.*	14.7 ± 0.51	4.16 ± 0.03	24.8 ± 0.19	12.6 ± 7.11
3-4 (6 specimens)	Mean	167.0 ± 6.97	80.5 ± 3.15	82.7 ± 4.23	38.2 ± 3.30
	Diff.*	49.0 ± 0.53	9.1 ± 2.50	21.5 ± 4.44	7.23 ± 3.55
<i>Potamogeton praelongus</i>					
Less than 1 meter (34 specimens)	Mean	140.0 ± 0.178	87.0 ± 2.33	103.0 ± 2.16	46.7 ± 2.35
1-2 (28 specimens)	Mean	153.0 ± 2.93	102.0 ± 1.85	131.0 ± 5.29	52.5 ± 1.57
	Diff.*	13.6 ± 4.64	15.0 ± 5.03	27.4 ± 4.66	5.78 ± 2.44
2-3 (7 specimens)	Mean	179.0 ± 7.95	107.0 ± 8.21	152.0 ± 14.90	49.3 ± 3.75
	Diff.*	25.7 ± 3.03	5.03 ± 0.59	11.3 ± 0.51	3.27 ± 0.80

\* Difference between this group and the preceding one.

#### DISCUSSION

The leaves of *Potamogeton richardsonii* and *P. praelongus* were thin and easily cleared for study. The presence of chloroplasts, which were found in the epidermis, was thought to be due to the reduced amount of light available to submerged plants (1). The cells of the epidermis are somewhat rectangular, a shape thought by E. Mer (*vide* 1) to be due to a constant state of turgescence because of the feeble "transpiration" of submerged plants, which allows a more uniform growth. Stomates or their vestigial indications were not found in the epidermis of the specimens studied.

Until Zalenski's study (*vide* 6) it was supposed that plants living in a dry environment were protected against excessive evaporation and that they had no need of a rapid water supply. It was also supposed that plants living under conditions of high humidity had structural adaptations for increased transpiration. Zalenski observed in 1901 (*vide* 6) that the network of veins was better developed in the leaves of plants growing in open habitats than in those of plants growing in the higher humidity of woodland shade. He also found that the upper and lower leaves of plants growing under these conditions sometimes showed no difference in density of venation. *Potamogeton richardsonii* and *P. praelongus*, being submerged aquatics living under conditions of low rate of "transpiration," showed no consistent decrease in areas of vein islets from the lowest to the highest leaf.

Since the constant decrease in size of cells and vein islets observed by Zalenski (*vide* 6) and others (2, 3, 4, 7) in upright terrestrial plants was not obtained in the submerged aquatics which were not exposed to the increasing drying effects of the atmosphere, the data gathered would seem to indicate that there must be other environmental factors not taken into consideration, that environment is a greater controlling factor than heredity, and that indirectly they are a confirmation of Zalenski's law.

#### SUMMARY

1. This investigation shows no consistent increase in size of lower epidermal cells or vein islets from apical to basal leaves of *Potamogeton richardsonii* and *P. praelongus*.

2. The data gathered from observations upon these aquatic species are not in agreement with observations made by Zalenski and others on terrestrial species.

3. The data may be interpreted to mean that environment has a greater influence than heredity in determining the size of cells and vein islets in the aquatic flowering plants studied.

4. It may be said that the observations indicate indirectly a confirmation of Zalenski's law.

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## PLATE I

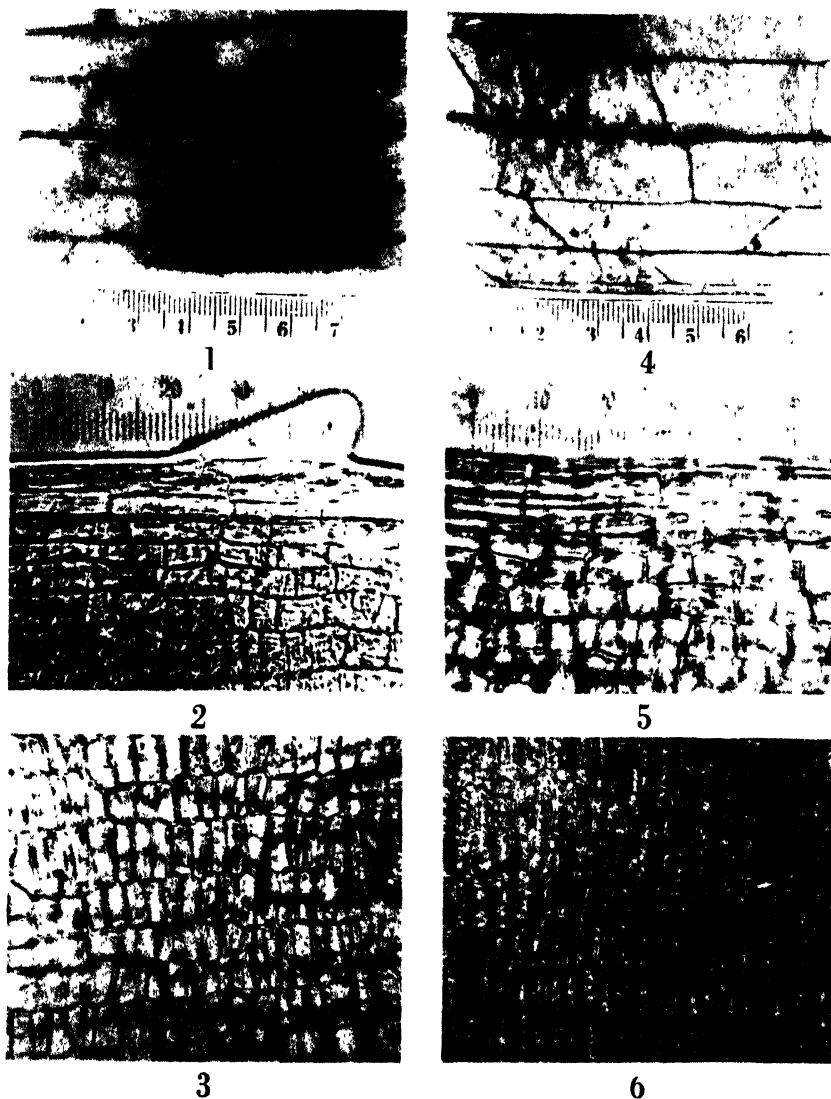


FIG. 1. Vein islets, *Potamogeton richardsonii*.  $\times 12.5$

FIG. 2. Marginal cells, *P. richardsonii*. One ocular unit.  $3.27 \mu$

FIG. 3. Central cells, *P. richardsonii*

FIG. 4. Vein islets, *P. praelongus*.  $\times 12.5$

FIG. 5. Marginal cells, *P. praelongus*. One ocular unit.  $3.27 \mu$

FIG. 6. Central cells, *P. praelongus*





# STUDIES IN THE GENUS PORIA\*

## I. *PORIA CARNEOPALLENS* (BERK.) COOKE

JOSIAH L. LOWE

**S**TUDY of *Poria* material now in the Farlow Herbarium from the southern United States and from the tropical regions of the Western Hemisphere revealed that widespread confusion existed concerning the identity of *Poria carneopallens*. The type collection alone of the specimens listed below was filed under its proper name, and an adequate idea of the distribution and incidence of this species depended upon a search for and restudy of the pertinent herbarium specimens.

The macroscopic and many microscopic characters of *Poria carneopallens* are closely similar to those of the common and widely distributed *Poria eupora* (Karst.) Cooke. The ranges of these two species overlap, and their close similarity has led to much confusion. The spore size and shape readily separate them (Fig. 1a, b), but southern material proved sterile more often than fertile. For this reason a character for the specific identification of sterile specimens was sought and found.

Positive distinction between these two species can be made by determining the nature of the thin-walled connective hyphae in the subiculum. In *Poria carneopallens* septa are regularly present but clamp connections are lacking, whereas clamp connections are regularly present on such hyphae in *Poria eupora*. It must not be supposed that septa or clamps are always readily seen, for in both species connective tissue may be so scanty and may break into such minute pieces on crushing that an oil-immersion lens frequently must be employed to observe this character. In so far as fertile material

\* Contribution from the Department of Forest Botany and Pathology, The New York State College of Forestry, Syracuse, New York, and from the Farlow Reference Library and Herbarium of Cryptogamic Botany at Harvard University, Cambridge, Massachusetts.

This study was supported in part by a grant-in-aid from the Society of the Sigma Xi.

provided a check, however, the taxonomic value of this character proved diagnostic.

Since a complete and modern description of *Poria carneopallens* has not been published, one is here appended.

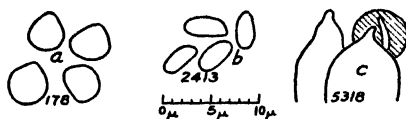


FIG. 1. Spores and cystidia in species of *Poria*:  
*a*, spores from the type collection of *P. carneopallens*; *b*, spores of *P. eupora* (from Lowe 2413); *c*, mammillate cystidia from original material of *P. fulvobadia* (no. 5318). A cross section of a cystidium showing the very thick walls is at the upper right

*Poria carneopallens* (Berk.) Cooke, *Grevillea*, 14:110. 1886  
*Polyporus (Resupinatus) carneopallens* Berk., *Hooker's Journ. Bot.*, 8:237. 1856.

Fruiting body annual, effused up to 10 cm., inseparable, without distinctive taste. Margin whitish to cream, narrow, appressed-tomentose. Pore surface varying from pale cinnamon to flesh color, faintly glancing, the tubes tough and somewhat cartilaginous when dry, up to 1 mm. long, the mouths angular, variable in size from 8 to 12 per mm., the edge narrow, entire, often whitened. Subiculum cream, up to 0.3 mm. thick, firm-fibrous.

Sections not changing color in potassium hydroxide solution, the fundamental hyphae of the subiculum rarely branched, nonseptate, 4–7  $\mu$  in diameter, and the connective hyphae abundant to rare, thin-walled, septate, and 2–4  $\mu$  in diameter. Cystidia abundant to rare, terminally incrusting, 7–11  $\mu$  in diameter; basidia clavate, 11  $\times$  4–6  $\mu$ ; spores hyaline, smooth, ovoid to subglobose, often with somewhat flattened sides and appearing more or less triangular, 3.5 – 4  $\times$  2.5 – 3.5  $\mu$ .

On the wood of deciduous trees, associated with a white rot. Specimens studied in the Farlow Herbarium: Brazil, Spruce 178, type collection; Cuba, W. L. White 376, 854, 858; Florida, R. Thaxter 90, and W. W. Calkins 792.

*Poria fulvobadia* Pat. (*Journ. Botanique*, 11:340. 1897) from Tonkin, French Indo-China, agrees in all the characters described

above and has, in addition, peculiar mammillate cystidia shown in Figure 1 c. Such cystidia were found in the type of *Poria carneo-pallens* after this manuscript was submitted for publication, and it seems certain that these two species are synonymous.

This species has also been reported from Brazil by Berkeley and Cooke (*Linn. Journ. Bot.*, 15:384. 1876), Bresadola (*Hedwigia*, 35:282. 1896), Hennings (*Hedwigia*, 43:199. 1904), and Theissen (*Kaiserlich. Akad. Wissensch. Wien, Math.-naturw. Kl., Denkschr.*, 83:239. 1911); from Cuba by Berkeley and Curtis (*Journ. Linn. Soc. London*, 10:318. 1868) and by Murrill (*Mycologia*, 11:22. 1919); from Guadeloupe and Martinique by Duss (*Flore cryptogamique des Antilles françaises*, p. 238 (or 28). 1904), as *Leptoporus*; from Nicaragua by Ellis and MacBride (*Bull. Lab. Nat. Hist. State Univ. Iowa*, 3:191. 1896) and by C. L. Smith (no. 81, Central American Fungi, 1896 — Farlow Herbarium specimen sterile and uncertain); from Paraguay by Spegazzini (*Bol. Acad. Nac. Cienc. Córdoba*, 23:425. 1919); from Venezuela by Patouillard (*Bull. Soc. Myc. France*, 4:35. 1888).

THE NEW YORK STATE COLLEGE OF FORESTRY  
SYRACUSE, NEW YORK



## NEW AND INTERESTING SPECIES OF BASIDIOMYCETES. II \*

ROLF SINGER

**D**URING a period of five years (1940-45) a large number of new and incompletely known species of Basidiomycetes from many parts of the world have accumulated "in schedulis" and in my notebooks. Some of these have appeared in the first part of this paper, and more will be published in future supplementary series.

### VIII. Two New BOLETES

#### **Suillus ruber** Sing. & Sipe sp. nov.

Pileo laete rubro, maculis obscurioribus adperso, viscido, subfibrilloso-verruculoso in siccis, maculis sordide carmineis, interstitiis pallidis, forma magnitudineque *Boletum pictum* aemulante. Hymenophoro viridulo-flavo in maturis, poris tubulisque in siccis colorem eorum *Suilli tomentosi* (Kauffm.) Sing. (*Boleti tomentosi* Kauffm.) simulantibus, poris angustis, vix amplis, adnatis; sporis pallide melleis vel melleis, paucis castaneo-brunneis, levibus, depressione suprahilari carentibus, tenuitunicatis,  $7.8-9.8 \times 2-3.4 \mu$ ; basidiis  $20-21 \times 5.5-6.2 \mu$ , tetrasporis; cystidiis aut  $24-32 \times 4.8-5.2 \mu$ , hyalinis, fusoides, aut usque ad  $50 \times 7.5 \mu$ , brunneo-incrustatis, clavatis, ambobus typis in eodem hymenophoro constanter praesentibus, secundi typi cystidiis in maculis minutissimis concentratis. Stipite flavo, glanduloso, solido, apicem versus subattenuato, evelato; glandulis e dermatocystidiis versiformibus, plerumque fusoides-cylindraceis vel fusoides-subampullaceis, fortiter castaneo-incrustatis, confertissimis,  $35-85 \times 4.5-12.5 \mu$  consistentibus; elementis aliis heterogenis (dermatocystidiis typi alterius,

\* The first part of this paper appeared in *Mycologia*, 37: 425-439. 1945.

The color terms used in this paper are those of Richard Crawshaw, *The Spore Ornamentation of the Russulas* (London, 1930); A. Maerz and M. Rea Paul, *Dictionary of Color* (New York, 1930); R. Ridgway, *Color Standards and Color Nomenclature* (Washington, D.C., 1930); E. Séguy, "Code universel des couleurs," *Encyclopédie pratique du naturaliste*, XXX (Paris, 1936).

dermatopseudoparaphysibus, dermatobasidiis) nullis vel perpaucis visis. Carne in pileo alba, in stipite flava, caerulescente in ambobus quando fracta est; odore nullo notabili; sapore miti. Sub coniferis (*Picea Engelmannii* et *Pino Murrayana* cum qua probabiliter mycorrhizam format), Septembri mense. Odell Creek, Oregon, U. S. A. occidentalis, America Borealis. F. P. Sipe, 333 (FH). Vide Pl. I. Inter Granulatos Sing. pileo rubro unica species, atque carne caerulescente eximie distincta est; fortiter e Hirtellinis.

***Xerocomus indicus* Sing. sp. nov.**

Pileo flavo, tomentuloso, pulvinato, levi, 10–20 mm. lato; cuticula ex hyphis filamentosis, plus minusve gelatinescentibus composita. Hymenophoro tubuloso, haud convexo; tubulis concoloribus cum pileo, longis, adnatis vel decurrentibus, poris concoloribus, pro ratione amplis, angulatis; sporis olivascence-brunneis in cumulo, sub microscopio melleis, parvulis, 5–6.5 (7.5)  $\times$  3.2–3.5 (3.7)  $\mu$ , levibus, depressione suprahilari subnulla; basidiis tetrasporis; cystidiis parvulis, sparsis; tramate in adultis typi Phyllopororum. Stipite subconcolori vel magis brunnescente, pro ratione firmo, subglabro, solido, subaequali, pilei diametro longiore, tenui; mycelio sparso, flavo. Carne subconcolori cum superficiebus; odore saporeque haud notatis; hyphis fibulis destitutis. In terra sub *Saccharo manja* Roxb. Ladhar St., India Orientalis. Sultan Ahmed, 44 (FH).

*Observations.* — The present collection does not afford an opportunity to examine the structure of the young stages, yet a comparison with *Xerocomus brasiliensis* (Rick) Sing. shows that these species must be extremely close, apparently belonging to the same section (Brasilienses Sing.). It cannot be established at present whether the pileus is ever viscid in fresh condition, but it may be assumed that it is. The main difference between this and *X. brasiliensis* is the smaller spores of *X. indicus*.

RUSSULACEAE

IX. THE GENUS LACTARIOPSIS HENN.

The group of agarics belonging in *Lactariopsis* was characterized by R. Heim in 1938 and by me in 1942, its status in both accounts being lowered to subgenus or section (of *Lactarius*). But in 1941

I received a collection of African fungi for determination among which were the original *Lactariopsis Zenkeri* Henn. (which is closely related to *Lactarius Pandani* Heim) and, also, a gymnocarpous species closely related to *Lactariopsis Zenkeri*. I was preparing this manuscript, in which I regarded the gymnocarpous species as new, belonging to an emended section *Lactariopsidei* (Henn.) Sing. (or *Lactariopsis* [Henn.] Heim as subgenus), when a set of papers published by R. Heim during the war reached me. Heim had, in one of these articles, not only described the same species (though without a Latin diagnosis, which is now supplied) that was deposited here under a new herbarium name, but also emended *Lactariopsis* much as I had intended to emend it. Heim says (*Boissiera*, 7:276. 1943): "On peut établir ce sectionnement, croyons-nous, sur l'existence d'un revêtement persistant, pileux ou membraneux, sur celle de *cystides* faciales, et secondairement sur des spores ovoïdes-ellipsoïdes à ornementation du type finement réticulé-verruqueux, enfin à l'habitat lignicole (bois mort) ou propre à un humus ligneux."

#### KEY TO THE SPECIES OF LACTARIUS, SECTION LACTARIOPSIDEI

- A. Pileus up to 30 mm. broad, without radial folds or veins; veil annular in most instances; Cameroons and Liberia  
*Lactarius Zenkeri* (Henn.) Sing.
- A. Pileus larger; surface with radial folds or veins; veil annular or appendiculate or wanting
  - B. Veil present; odor none; Madagascar . . . . . *Lactarius Pandani* Heim
  - B. Veil none; odor disagreeable; Côte d'Ivoire, Haute-Guinée, Liberia, Cameroons . . . . . *Lactarius gymnocarpus* Heim

I have nothing to add to the description of *Lactarius Pandani* Heim; see *Les Lactario-Russulés du domaine oriental de Madagascar* (Paris 1938), page 37.

#### **Lactarius Zenkeri** (Henn.) Sing., Ann. Mycol., 40:111. 1942

*Lactariopsis Zenkeri* Henn., Engler's Bot. Jahrb., 30:51. 1901.

Pileus red brown with light-colored margin in button stage, then orange brown at the center, light tan at the periphery, floccose-pubescent, with the margin at first involute, then repand and striate, convex with a slight depression in the center, becoming gradually

flatter or even infundibuliform in some specimens, 10–30 mm. broad. Lamellae cream-colored, then light tan, dirtier when bruised but not actually changing color, close, adnate, rather narrow (1–3 mm. broad); spore print not obtained. Stipe cream-colored at the apex, light tan below, flocculose, subequal or tapering downward, spongy-solid,  $25\text{--}35 \times 3\text{--}6$  mm.; veil connecting the incurved margin of the pileus with the apex of the stipe and later forming an apical annulus in most specimens.<sup>1</sup> Context cream-colored in pileus and stipe; latex probably sparse (not noticed by the collector); odor disagreeable.

Spores  $8.5\text{--}12 \times 7.5\text{--}10.5 \mu$  (rarely reaching the upper limit), with ornamentation  $0.5\text{--}1.2 \mu$  high, consisting of warts or cylindric spines connected by fine lines, type IIIa in mature spores, but in young spores type I or II, with the hilar appendage far off the lower axial pole, hyaline, oil droplet small or, more often, large; basidia  $31\text{--}38 \times 9\text{--}15 \mu$ , 4-spored; cystidia  $68\text{--}110 \times 10.5\text{--}16 \mu$ , with scattered to coarsely massed (as in *Russula congoana*), banded contents, usually subcylindric with one or two ventricose thickenings at the base and near the apex, more rarely equal or clavate, the apex sometimes with a granular crystalline incrustation; cuticle of pileus beset with an outer layer of hairs, these hairs thick-walled, subulate, nonpseudoamyloid, nonamyloid, with obtuse or subacute apex, with a double wall (the external one about  $0.5 \mu$  thick, the internal one  $1.5\text{--}2.5 \mu$  thick; later the entire wall reaching  $3.5 \mu$ ),  $35\text{--}300 \times 5\text{--}9 \mu$ ; gill trama consisting of laticiferous hyphae, other hyphae inconspicuous in young specimens, later with many connective hyphae which are, however, often irregularly inflated and sphaerocystoid, but the trama not truly heteromerous except for the upper (thicker) end of the lamellae near the flesh of the pileus in old specimens; mycelium consisting of thick-walled, hyaline, clampless hyphae; veil consisting of thin-walled, thin, flexuous hyphae, which at the surface often merge into thick-walled hairlike hyphae, all hyaline; context of the stipe truly heteromerous from the beginning, consisting of rather large sphaerocysts (e.g.  $55 \mu$  in diameter) and connective hyphae; all hyphae without clamp connections.

*Habitat and distribution.*— On humus and well-rotted wood,

<sup>1</sup> If Heim's drawing (*Les Lactario-Russulés*, p. 43, fig. 11) of the Madagascar species (*L. Pandani*) is compared, it should be noted that the line of rupture is along A—B in *L. Zenkeri*.



densely gregarious to clustered, during the early rains (April). Cameroons (type locality) and Liberia (near Nengbe), G. W. Harley, 57.

*Lactarius gymnocarpus* Heim (cf. Boissiera, 7: 273, fig. 27. 1943, sine diagnose Latina)

Pileo radialiter venoso, subflocculoso-tomentuloso, aurantiaco-brunneo, subaurantio ad marginem, c. 75 mm. lato; cuticula crinibus crasse tunicatis obsita. Lamellis cremeo-albidis, subdecurrentibus, distantibus, heterophyllis, dimidiatis intermixtis, 10 mm. latis, ceraceis, tenuibus; sporis albis, sub microscopio hyalinis,  $7.7\text{--}11 \times 6\text{--}8.5 \mu$ , ornamentatione  $0.3\text{--}1.4 \mu$  alta, subcristulata vel verruculoso-reticulata, asymmetrice hilatis; basidiis tetrasporis, rare bisporis; cystidiis fusoides vel subclaviformi-filamentosis, acutis vel obtusis; tramate lamellarum sphaerocystis sat numerosis praedito. Stipite pileo concolori ad apicem, ad basin albostrigoso, vestito sicut pileus, spongioso-molli-subfragili, versiformi, base saepe sulco angustiore a parte altera separata. Carne in pileo alba, in stipite crenea; latice albo; sapore miti; odore ingrato. In humo lignoso. Africa tropicalis occidentalis (Côte d'Ivoire, Haute-Guinée, Liberia, Cameroons).

*Observations.* — In the Liberian specimens the veins of the pileus were anastomosing; the wall of the hairs of the epicutis was  $1\text{--}5 \mu$  thick, thicker toward the base of the hairs, the hairs forming a palisade on the umbilicate, plane pileus; the spores were of two rather sharply separated types, either large ( $9\text{--}11 \times 7.5\text{--}8.5 \mu$ ) with high ornamentation ( $0.8\text{--}1.4 \mu$ ) or small ( $7.7\text{--}9 \times 6\text{--}7.5 \mu$ ) with lower warts or ridges ( $0.3\text{--}0.4 \mu$ ); these spores were found in the specimens at the same time, and both evidently belonged to the common carpophore; the smaller ones were in the majority. The latter type must have been retarded in their development, for this is probably not a specific character. The type of ornamentation was, as may be expected, also rather variable in the Liberian specimens (II, IIIa, IIIb, IV). The stipe was about  $40 \times 10$  mm. The plant grew on humus in the tropical forest, solitary.

R. Heim must choose a type specimen. According to him, the pileus can reach 175 mm. in diameter, the cuticle is nonseparable, there are 14–22 lamellae running out on the stipe into longitudinal veins, and the stipe is tuberculate-scröbulate besides; the flesh

stains black or brown in a rather inconstant manner; the latex is seriffuous, unchanging, and mild;  $\text{FeSO}_4$  turns the context of the pileus a bright blue green.

X. A SOUTH AMERICAN REPRESENTATIVE OF *RUSSULA*,  
SEC. PELLICULARIAE

***Russula brasiliensis* Sing. sp. nov.**

Pileo fusco, glabro, convexo, margine late (per tertiam marginalem radii) pectinato-fisso Coprinorum modo, acutiusculo, 40–50 mm. in diametro in statu vegeto aestimato; dermatocystidiis nullis visis; lamellis subangustis, subaequalibus, simplicibus, venis transversalibus connexis, liberis vel subliberis; sporis albidis aestimatis (verosimiliter plus minusve B Crawshayi), sub microscopio subglobosis, c.  $10.5\ \mu$  in diametro, ornamentatione cristato-reticulata (typi I, mox II–IIIa–IIIb, cristulis cuneatis verrucisque  $1.5\text{--}2\ \mu$  altis), membrana melleo-hyalina (subhyalina) praeditis, subsymetricis *Russulae annulatae* modo; basidiis c.  $38 \times 13\ \mu$ ; cystidiis versiformibus, membrana plerumque plus minusve incrassata instructis ( $0.5\text{--}1.1\ \mu$ ), compluribus granulatione flavida impletis,  $50\text{--}65 \times 12\text{--}13\ \mu$ . Stipite subconcolori vel albido (discolorato siccando), tenui, subaequali vel ad apicem attenuato, ad basin indistincte discoideo vel haud discoideo, exannulato. Carne pallida, exsiccatione leniter fuscata; odore saporeque haud indicatis. In terra sabulosa. Rio Grande do Sul, Brasilia. J. Rick (ut *Russula pectinata*), Herbarium Patouillard (FH).

*Observations.* — This species is similar to *Russula pectinata*, which is common in North America south to tropical south Florida and perhaps to Brazil. The specimen studied, however, which was sent to Patouillard by Rick as a sample of what he called (and published as) *R. pectinata*, is not that species because of the entirely different spores and surface characters. It belongs in the subsection Discopodinae Heim of the section Pelliculariae Heim, whose representatives have thus far been collected in Africa only. The subsymmetrical spores are very much the same as those found in the Discopodinae, and it is mainly the color of the carpophore (not bright-colored anywhere) that distinguishes the Brazilian species from the African ones. *R. brasiliensis* differs from *R. annulata* var. *exannulata* Heim in the color of the pileus, the less developed or not developed basal disc, the sometimes thick-walled cystidia, and probably in other

characters not now obvious because of the lack of notes on the fresh specimens.

The structure of the cuticle of this species in unexpectedly complicated. The uppermost layer (epicutis) is composed of hairlike elements, some of which usually consist of elongated members of 4–5.5  $\mu$  in diameter, which contain amorphous or, even, banded contents. These elements form a palisade immediately upon the lower layer. The subcutis is made up of interwoven, hyaline hyphae running in all directions, embedded in a gelatinous mass, and very loosely arranged; no clamp connections are present. Beneath the subcuticular layer there is a third layer of pigmented hyphae which are more regularly tangentially arranged, subparallel, denser, and not gelatinized; then, farther below, the context of the pileus, intermixed with numerous sphaerocysts, begins. The layer of pigmented hyphae corresponds to what is usually called "hypoderm" in the Agaricales (but not in the Russulaceae). I think that the term "hypoderm" would be correct in this case, and should be applied generally if the infra-epicuticular layer is divided into two strongly differentiated zones.

XI. A NEW SPECIES OF *RUSSULA*, SEC. *COMPACTAE*,  
SUBSEC. *NIGRICANTINAE*

***Russula albonigroides* Sing. sp. nov.**

Pileo livescenti-griseo-fusco, dein atrofusco, levi, udo, concentrice canaliculato in compluribus, convexo, demum concavo, cuticula glabra, adnata margineque acutissimo, levissimo, tenui gaudente, 35–70 mm. lato; cuticula pilei submonostrata, ex hyphis irregulariter dispositis, fuscatis, levibus, filamentosis, 2–9  $\mu$  crassis consistente; sub cuticula sphaerocystis carnis obviis (e.g. 60  $\mu$  in diametro). Lamellis pallide alutaceis in maturis, nigricantibus, 3 mm. latis, angustioribus carnis crassitie aut aequantibus eam, confertis vel confertissimis, de centro radii pilei angustatis intus extusque, tenuibus, subdecurrentibus; sporis 7.7–9.5  $\times$  6.5–7.5 (7.7)  $\mu$ , asymmetricis, ellipsoideo-globulosis, hyalinis, ornamentatione reticulata areas polygonas delimitante, 0.5–1.5  $\mu$  alta (i.e. elatissima), typi II–IIIa vel I, spinulis, ubi exstant, plerumque cylindraceis, crassiusculis; basidiis 35–43  $\times$  9.5–12  $\mu$ , tetrasporis, subinde fusoideis at plerumque clavatis; cystidiis 58–78  $\times$  6.5–9  $\mu$ , hyalinis vel fuscatis in siccis, e tramate radicanibus, subfusoideis vel fusoideis aut subclavatis, saepe

capitatis vel appendiculato-capitatis, nonnullis intus vermiformiter granulosis; tramate subvesiculososo (sphaerocystis abundantibus). Stipite griseolo, nigrescente, evelato, cylindraceo, circa  $40 \times 15$  mm. Carne alba, in stipite sordide albida, fracta nigrescente, in siccis nigra, in pileo submolli, in stipite dura; odore nauseoso; sapore ignoto, probabiliter haud fortiter acri; hyphis defibulatis. In silvis tropicalibus sparse. Jove siccior. Ganta, Liberia, April 19, 1939. G. W. Harley, 77, typus (FH), et Tjibodas, Java, 1908, F. v. Höhnel (FH).

*Observations.* — The specimen from Java is preserved in the Höhnel Herbarium, and is determined by Höhnel as "*Russula adusta?* — kaum etwas anderes." Here the spores are slightly smaller, but far from comparable with spores of *R. adusta*.

## XII. MORE NEW TROPICAL RUSSULAE

### *Russula Hoehnelii* Sing. sp. nov.

Pileo flavido vel pallide brunneo-ochraceo in maturis, ochraceo-brunneo in siccis, secco, verruculoso, verrucis densioribus coloreque saturatiore centrum versus ubi superficies subintegra videtur, interdum subsquamoso-rupto, rugoso-costato supra dorsum lamellarum, convexo centro depresso, 33 mm. lato in siccis; epicute e crinibus ascendentibus, versiformibus, ad apicem rotundatis, levibus, hyalinis, intus haud granulosis,  $3.5\text{--}6$  (9)  $\mu$  latis consistente; subcute ex hyphis plus minusve tangentialiter dispositis, subparallelo-subintertextis, filamentosis efformata, subtus autem gradatim in contextum pilei sphaerocystis intermixtum transeunte. Lamellis ochraceo-cremeis, anastomosis paucis transversalibus connexis, aequalibus vel subaequalibus, simplicibus, sublatiis (4 mm. latis in statu sicco), admodum distantibus (30–35), usque ad 5 mm. distantibus ad marginem, adnexo-attenuatis vel subdecurrentibus; sporis in massa non visis; sporis  $6.3\text{--}6.8 \times 4.5\text{--}5.5$   $\mu$ , ornamentatione 0.2–0.3  $\mu$  alta, typi VI, raro IV; basidiis gracilibus,  $35\text{--}45 \times 5\text{--}7$   $\mu$ , tetrasporis; sterigmatibus  $4.5\text{--}5$   $\mu$  longis; cystidiis paucis, subbasidiomorphis, saepe breviter appendiculatis; cheilocystidiis saepe e tramate ortis, versiformibus, saepe e cellula late cylindracea basali ecrescentibus, aut e compluribus talibus cellulis catenulatis ecrescentibus, e.g.  $23 \times 8$   $\mu$ , vel minoribus; subhymenio bene evoluto, ramuloso, c. 25  $\mu$  crasso; tramate lamellarum e sphaerocystis (e.g.  $33 \times 31$   $\mu$ ) et hyphis connectivis numerosis tenuitunicatis, nonnullis autem crasse

tunicatis (membrana usque ad  $1.5\ \mu$ ) consistente. Stipite concolori, basin versus acuminato-attenuato, sublevi, nudo, glabro vel subglabro, farcto, c.  $25 \times 7$  mm. in siccis. Carne albida; odore saporeque ignotis. In terra. Tjibodas, Java, F. v. Höhnelt (FH).

*Observations.* — This species is like *Russula archaea* Heim in appearance. The cuticle is much like that of *R. fistulosa* Heim form B, from which our species differs in spore ornamentation and other characters, e.g. the very distant lamellae. *R. archaea* has a similar cuticular layer, but is, at the same time, said to be glabrous. The spores of our species agree with those of *R. archaea*, and so do the cystidia, which are very scattered and inconspicuous. Our species differs mainly in the verruculose pileus (but the density of the warts on the disc is such that the surface appears almost smooth) and in the constantly 4-spored basidia and the thinner lamellae, which in *R. archaea* are often bifurcate or accompanied by lamellulae.

It seems to me that *Russula archaea* is for the most part quantitatively different from a few similar species, among them *R. Hoehneltii*, *R. Earlei*, and *R. fragilissima* Heim. At one time I would have regarded them as belonging in subsection Elephantinae, but it now appears that the subsection is not so natural as the other subsections used in *Russula*. In fact, the part of the Elephantinae in which the species named above belong should now rather be known as Archaeinae Heim, whereas the type species of the subsection (*R. mustelina* = *R. elephantina*), along with the subsection, is quite closely related to some groups of the Rigidae, rather than to the Compactae. In the subsection Elephantinae emend. belong *R. elephantina* Fr., *R. subalbidula* Murr., and probably *R. persobria* Kauffm. ex Sing. On the other hand, the species of the Archaeinae named above are somewhat intermediate between the subsection Delicinae of the Compactae and Fistulosinae of the Ingratae. They can be distinguished from one another by the following key:

A. Spores with mostly isolated punctation

B. Pileus up to 50 mm.; tropical species

C. Lamellae forked, intermixed, and, comparatively, very thick;  
pileus glabrous; basidia 2-spored and 4-spored

*Russula archaea* Heim

C. Lamellae mostly simple and equal; pileus warty; basidia all 4-spored . . . . . *Russula Hoehneltii* Sing.

B. Pileus larger; American (temperate) species . . . . . *Russula Earlei* Peck

A. Spores with reticulating connecting lines between the warts

*Russula fragilissima* Heim

**Russula liberiensis** Sing. sp. nov.

Pileo fuligineo-fusco, rimosello-granuloso e verruculis punctiformibus, centro leviores, margine extremo striato, demum infundibuliformi, c. 60 mm. lato; granulis e sphaerocystis accumulatis, saepe ovoideis, paucis in hyphas ellipsoideas vel cylindraceas elongatis, omnibus crasse tunicatis, constantibus; pigmento intracellulari dissolutoque et granuloso-globuloso ochraceo-brunneo manifesto; membranis  $0.6-2\ \mu$  crassis, refringentibus. Lamellis albis, brunnescentibus fractu, sublinearibus, haud ventricosis, angustis, lamellulis perpaucis intermixtis, tenuibus, adnexis, confertissimis; sporis in cumulo haud visis, probabiliter albis vel albo-cremeis, sub microscopio  $6.8-9.5 \times 6-8.8\ \mu$ , distincte asymmetricis, subglobosis, plerumque  $7-7.5 \times 6-6.5\ \mu$ , ornamentatione  $0.2-0.5\ \mu$  alta, cristulato-reticulata (typi I); basidiis c.  $24 \times 7\ \mu$ , tetrasporis; sterigmatibus  $5-5.5\ \mu$  longis; cystidiis  $32-53 \times 4-10.5\ \mu$ , versiformibus, clavatis, fusoides, etc., apice acutis vel rotundato-obtusis, intus granulosi vel corpusculis vermiformibus impletis; tramate sphaerocystis numerosis praedito. Stipite cremeo-albido, tactu brunneolo-albido, furfuraceo-granuloso, spongioso, solido, aequali, c.  $55 \times 14$  mm.; granulis e corpusculis eis pilei similibus, sed magis elongatis, plerumque catenulatis efformatis; membranis individualibus catenulae  $5.5-13\ \mu$  crassis, membrana c.  $0.7\ \mu$  crassa, intus subgranulosis. Carne alba, in pileo fragili, in stipite spongioso; odore terreo; sapore haud notato; sulphovanillinae actione haud mutata sed granulis externalibus nonnullis brunnescentibus. In terra humosa, verne. Nengbe, Liberia. G. W. Harley, 50.

*Observations.* — This species belongs in the subsection *Fistulinae* Heim of the section *Ingratae* Qué. and, because of the thick-walled epicuticular bodies, is closely related to *Russula crassotunicata* Sing. from North America.

XIII. THREE SPECIES OF *RUSSULA*, SEC. DECOLORANTES

**Russula rubriceps** (Kauffm.) Sing., *Mycologia*,  
35: 151. 1943

*Russula decolorans* var. *rubriceps* Kauffm., Rep. Mich. Acad., 13: 215. 1911.

Pileus evenly red (bright *emetica*-red; "scarlet red" [R.], to "nopal red"), the center sometimes stained with pallid spots,

opaque, convex with depressed center, with smooth, later tuberculate-sulcate, subacute, later obtuse and even often rounded, margin, large (70–90 mm. in diameter), with glabrous to subglabrous cuticle that is separable in the outer third of the radius, and viscid in wet weather. Lamellae stramineous-ochraceous when mature, broad (about 12 mm.), frequently intermixed with some lamellulae, anastomosing with low veins, some forked or all simple, not ventricose, adnate, later separating from the stipe, subdistant to crowded, most frequently close; spore print between D (Crawshay) and E, nearer E, but more salmonaceous. Stipe white, the apex often pink, almost constantly ventricose, or subventricose, subrugulose, firm, eventually somewhat fragile,  $70-90 \times 16-32$  mm. Context white, reddening on injury, then becoming dark gray; red discoloration as well as subsequent gray one especially evident on stipe upon the slightest scratch. Odor of the fresh context none, later like that of cheese (Camembert); taste mild.

Spores  $8-10 \times 7-8.5$   $\mu$ , yellowish, short-ellipsoid-subglobose, echinulate, ornamentation projecting about  $1.3$   $\mu$ , consisting of cylindric spines, which are usually isolated (type VI), but when observed under oil immersion lens can be seen to have extremely fine lines connecting some of the spines (IV, IIIb, IIb), rarely some of the spines fusing into each other to form short ridges (II–IV); basidia  $30-39 \times 10-10.8$   $\mu$ , 4-spored; sterigmata  $7$   $\mu$  long; pseudocystidia  $40-80 \times 8-10.5$   $\mu$ , fusoid or clavate, obtuse, entirely and evenly blue in sulphovanillin, rather infrequent or, more often, rather numerous; epicutis with a moderate number of well-developed pseudocystidioid dermatocystidia shaped like those of the hymenium, usually with a large blue body in the middle when seen in sulphovanillin.

*Chemical characters.* — Context turning red (quick and strong reaction) with formalin.

*Habitat and distribution.* — Under various trees (*Tsuga canadensis*, even in pure stands, but also in oak woods; according to Kauffman, under *Pinus strobus* and *Fagus grandifolia*) in not too dry places in hilly woods, as well as in low places, usually gregarious, from June till fall. From New England west to Michigan; and south to Virginia.

*Observations.* — *Russula rubriceps* is common in Massachusetts and can easily be distinguished from *R. rubescens* Beardsl. by its

bright red pileus and larger size. Under ideal circumstances *R. rubescens*, *R. rubriceps*, *R. vinosa*, and *R. seperi* all turn red before staining gray or black when scratched, and this character is of no value in distinguishing these species.

*Russula vinosa* Lindb. ssp. **occidentalis** Sing. ssp. nov.

A subspecies typica differt magnitudine majore, colore magis ardesiaco-violaceo vel viridello in pileo, sporis majoribus spinis longioribus echinatis. America Borealis occidentalis.

Since I have already given a rather complete description based exclusively on this Western form, or rather race (*Bull. Soc. Myc. Fr.*, 55:257. 1939), I have only to add some supplementary notes here.

Pileus not only "Prussian red" (R.) or "haematite red," but also frequently "deep purplish vinaceous," and mixed with "vetiver green" or, later, "tea-green," margin usually remaining "dull lavender," but sometimes almost entirely olivaceous with only a faint lilac tinge,<sup>2</sup> center sometimes almost black. Spore print near "Naples yellow," between D (Crawshay), F, and E in a good print, generally nearer to E. Spores with ornamentation of type VI or, just as frequently, type IV, warts (1.0)1.5 (2.0)  $\mu$  long, spores always of size indicated by me (9-14  $\times$  8.5-12  $\mu$ ), never smaller.

*Distribution.* — Apparently a geographic race confined to the states along the Pacific coast and the Rocky Mountains, U. S. A., having been found in Idaho (Kauffman), Oregon (A. H. Smith), and probably Washington (Murrill; see Burlingham, *Mycologia*, 5:309. 1913).

*Russula pseudolepida* Sing., *Bull. Soc. Myc. Fr.*,  
55:251. 1939

This very variable species has already been described from material collected by C. H. Kauffman in Maryland and was tentatively put in the section *Rigidae*, subsection *Lepidinae*. Abundant fresh material, collected in New England, enables me now to publish an emended description that will prove that *Russula pseudolepida*, in spite of its external appearance, belongs in the section *Decolorantes*,

<sup>2</sup> These colors are taken from notes by A. H. Smith on material from Oregon determined by R. Singer (Mich., FH).



subsection *Xerampelinae*. The chemical characters indicated here would hardly be expected, and Heim's contention that the *Xerampelinae* and the *Lepidinae* are closely related seems to become more likely again.

Pileus in all colors occurring in *Russula lepida*, but also in some special colors or color combinations, such as "troubadour" (Maerz and Paul), "Red Cross," "Afghan red," "checkerberry," "old red," or an even darker red in places, or one of these vivid reds or "jasper red" (R.), or "Pompeian red" mixed with yellow blotches ("antimony-yellow" to between "maize-yellow" and "buff yellow"), both colors bleaching in age, the red becoming "light grayish vinaceous" to "hydrangea red," the yellow becoming "cream-buff" to "chamois," sometimes also with white spots, these eventually growing larger and the reddish parts disappearing more and more, not infrequently, also, rather pale or yellow from the beginning (much like the final stage of the mottled bright-red-bright-yellow form), with only a little pink in the middle or with the reddish color blended with the yellow so as to seem "zinc-orange," smooth, usually very opaque when dry, subglabrous to subvelutinous, frequently sub-pustulose-subgranular in the very center, the cuticle separable, with some difficulty, part way from the margin, or in the more fragile forms more easily separable for up to two thirds of the length of the radius, with the margin smooth and rounded-obtuse, convex at first, then depressed in the center, 50-120 mm. broad. Lamellae white when young, but turning a very pale creamy ochraceous in age and darker when dried, sometimes whitish pruinose from the spores, with numerous low anastomoses, equal or subequal, medium broad (6-8 mm. in an average specimen), subclose to crowded, simple or with a few forked ones among them, variably adnexed, often somewhat sinuate, emarginate, adnate, or subfree; spore print B (Crawshay). Stipe white, but in some of the uniformly bright-red specimens partly pinkish red (near color shown in pl. I, 1-2, of Maerz and Paul, or deeper), but more frequently without any reddish tint, glabrous, subrugulose, subequal to equal, or tapering downward, more rarely tapering upward, varying from medium or short in the firmer specimens to more elongate in the paler, fragile specimens, stuffed in the latter, solid in the former, 35-80 × 12-26 mm. Context white, firm or, more rarely, fragile, especially in the paler, slender forms, unchanging or almost so, rarely becoming

very slightly sordid, never staining distinctly yellowish or brownish when wounded or in age or on drying; mild (i.e. not acrid), and at the same time more or less bitterish to distinctly bitter; usually inodorous, but developing a sweetish odor (like that of *R. emetica*) when dried, or an odor of chocolate or benzaldehyde.

Spores  $8-11 (11.5) \times 6.8-9 (9.2) \mu$ , strongly echinulate, hyaline, asymmetric, short-ellipsoid-subglobose, ornamentation of types IIIa, IIIb, IV (one of these may be entirely absent in an individual print), often with some spines having rather thick connecting lines (II, II-IIIa, II-IIIb, II-IV), or with rather isolated spines (V, VI), but these always in the minority, projecting  $(0.4)0.6-0.9 \mu$ , sometimes in a print a number of spores having ornamentation projecting up to  $1.3 \mu$ ; basidia  $28-44 \times 9.5-12 \mu$ , 4-spored, occasionally very few 2-spored; sterigmata  $6-10.5 \mu$  long; cystidia on edges and sides of lamellae, not bluing in sulphovanillin, empty or granulose inside, the granulosity usually confined to the upper portion of the cystidia,  $62-100 \times 6.5-13.2 \mu$ , more numerous at the edges, there often narrower and long-appendiculate or sometimes capitate, otherwise similar to those on the sides of the lamellae, which are versiform (cylindric, fusoid, subulate, short-appendiculate or nonappendiculate, acute or obtuse); cheilocystidia nonpseudocystidioid, scattered to numerous, cylindric-filiform or subulate, more rarely fusoid, refringent, sometimes branching,  $2.5-7 \mu$  broad, of variable length, acute, more rarely obtuse; edge of lamellae simultaneously subheteromorphous (because of denser cystidia) and heteromorphous (because of the cheilocystidia); epicutis of pileus without pseudocystidioid dermatocystidia but with cheilocystidioid hairs or similar hyphae ends which have walls  $0.5-1.5 \mu$  in diameter, smooth and hyaline; aside from these, more or less numerous primordial hyphae with colorless or yellow incrustations usually present, their terminal members often fusoid or clavate,  $4-5.5 (7.5) \mu$  in diameter; hyphae of the subcutis thin-walled, not erect, filamentous, hyaline or with easily dissolving pigment, clampless.

*Chemical characters.* —  $\text{FeSO}_4$  reaction on flesh, pale sordid gray, slowly becoming pale to dark olive gray, more distinctly olive in the interior of the adult stipe, more orange buff in the lamellae. Aniline, after about ten minutes, from light sordid red to distinctly positive, as in *Russula xerampelina*. Formalin, in interior of stipe, rapidly pale brown, otherwise almost negative, or negative. Phenol normal

(chocolate color). Methylparamidophenol, slowly to rapidly strongly positive (deep violet, eventually black).  $\text{NH}_4\text{OH}$  everywhere negative. KOH and  $\text{HNO}_3$  on pileus negative. Sulphovanillin on dried flesh and surface of stipe exactly as in *R. Zvarae* ("Tommy red," "bonfire," soon "Red Cross," or deeper carmine purple on surface, "Russian calf" in interior of stipe). Chlorovanillin not deeper than "baby-rose," "candy-pink," "coral," "confetti," "sunglow," pallescent after a while.<sup>3</sup>

*Habitat and distribution.* — Consistently in mixed woods, usually near oak mingled with *Tsuga canadensis* or *Betula* sp. or both; generally in small to large groups; fruiting from July until October, most frequently (commonly in some regions) in August and September. From New England south to Virginia; western limits unknown.

*Material studied.* — New Hampshire: Alton Bay, D. H. Linder, 1944 (FH), two collections. Massachusetts: Harvard, Harrie Dadmun and R. Singer, 1945 (FH); Lynnfield, R. Singer, 1943 (FH); Wakefield, R. Singer, 1943 (FH). Pennsylvania: Gretna Park, C. H. Kauffman (as *Russula borealis* f. *gretnana*), cotype (Mich.). Maryland: Tacoma Park, C. H. Kauffman (as *R. aff. lepida*), type (Mich.). Virginia: Mountain Lake, R. Singer, 1946 (FH).

*Observations.* — This species is rather frequent in its area, and is generally determined as *Russula lepida*, from which it differs abundantly in the lack of the dermatopseudocystidia on the pileus, the larger, more strongly ornamented, and, on the average, more reticulated spores, the reaction with  $\text{FeSO}_4$  and aniline, and other less important characters. It also differs from all other species of the Lepidinae in the reaction with  $\text{FeSO}_4$  and aniline. It differs from *R. xerampelina* in the absence of discoloration after bruising and in the lack of a trimethylaminous odor, also in the lack of any bluing bodies in sulphovanillin and in the bitterish taste. It differs from *R. oreina* Sing. in the habitat, the bitter taste, and the lack of brownish discoloration and of dermatopseudocystidia on the pileus, as well as in the colors. *R. pseudolepida* and *R. oreina* are characterized by the same chemical features as the other Xerampelinae and by the absence of the odor which occurs in *R. xerampelina* and *R. compacta*.

<sup>3</sup> *R. rosea* matches pl. 1, L6, then pl. 2, L6, then pl. 3, L6, then pl. 4, L6 (Maerz and Paul) in the interior as well as on the cortex.

XIV. REDESCRIPTION OF *RUSSULA AMERICANA*

*Russula americana* (Sing.) Sing., Bull. Soc. Myc. Fr.,  
55: 264. 1939

*Russula rosacea* var. *americana* Sing., Bull. Soc. Myc. Fr., 54: 146. 1938.

Pileus uniformly bright red (about "nopal red" [R.]), very viscid but drying rapidly, glabrous, smooth to rugulose, strongly shining to opaque depending on the degree of viscosity on drying, moderately thick, broadly convex, the center applanate or becoming depressed, with margin eventually slightly tuberculate-striate but never rounded, pellicle separable with difficulty part way from margin, wounds reddish or becoming so, (30) 50–60 mm. broad. Lamellae white, becoming dull cream-color, close or subdistant, more often subdistant (in fully mature specimens), adnate or subdecurrent, more often subdecurrent (in fully mature specimens), anastomosing or deeply forked, a few conspicuously forked near the stipe, moderately broad, broadest in the marginal third; spore print D (Crawshaw) in intensity, but tone near "Naples yellow" (R.), "light buff," or "cartridge-buff." Stipe "geranium-pink," usually uniformly so up to the lamellae, though occasionally spotty, subrugulose, at least when mature, at times subpruinose at the apex, or almost furfuraceous, otherwise glabrous, solid or stuffed, becoming hollow, 40–60 × 10–15 mm., subequal or thicker at the apex. Context white, unchanging, but reddish under the cuticle and, often, along the surface of the stipe and in wounds, rather fragile (more so than *Russula rosacea*); taste more or less rapidly intensely acrid, or at least with a distinct burning aftertaste; odor not remarkable.

Spores (8.5) 9–11 (11.5) × (7) 8.2–9.5 (10.8)  $\mu$ , yellowish hyaline, densely warty, ornamentation of type IV, V, or VI, more rarely IIIb, projecting 0.6–1.0  $\mu$ , more rarely a number of neighboring warts combining into a short ridge (IV–II); basidia 37–42 × 9.5–10.2  $\mu$ , 4-spored, pseudocystidia 60–88 × 6.8–14.5  $\mu$ , usually fusiform, the broadest part in the middle or, more often, in the upper third, with banded contents in almost its entire length, turning blue in sulphovanillin, the apex usually attenuate-rounded, rarely with button-like appendage, or with a crystalline hood, very numerous; edge of lamellae homomorphous; epicutis of pileus with numerous versiform dermatopseudocystidia (66–100 × 2–8  $\mu$ ).

*Chemical characters.* — Chemical reactions not studied.

*Habitat and distribution.* — Under conifers such as *Abies* and *Tsuga*, on the ground; fruiting in September and October. Western U. S. A. Washington: Noisy Creek, Baker Lake, A. H. Smith, 16672 (FH), also collected by C. H. Kauffman (as *Russula rosacea* Fr.) (Mich., LE). Oregon: South Fork of Salmon River, Mount Hood, Gruber and Smith, 19151 (Mich., FH), 19505 (Mich.); swamp at Bear Springs, Mount Hood, A. H. Smith, 19221 (Mich., FH). California: A collection from the San Francisco Bay region, brought in by a member of the California Mycological Society in 1932 (?) and determined by V. Mentzer as *R. sanguinea* (Bull. ex Fr.) Fr., which grew among needles on the ground, is probably *R. americana* (FH).

*Observations.* — This beautiful species, recently re-collected and sent to me by A. H. Smith, is closely related to *Russula rosacea* Fr., from which it differs in the larger spores and the more fragile flesh and in the habitat. It also differs from *R. rhodopoda* Zvára in the different habitat, larger and less reticulated spores, and deeper spore-print color. *R. rubicunda* can be distinguished by its less strongly and less constantly red stipe and its habitat under hardwoods.

## TRICHOLOMATACEAE

### XV. ADDITIONAL DATA ON CATATHELASMA AND ARMILLARIA

#### *Catathelasma ventricosum* (Peck) Sing., Rev. d. Mycol., 5 : 9. 1940

*Armillaria ventricosa* Peck, Bull. Torr. Bot. Club, 23 : 414. 1896.

When studying the European *Catathelasma imperiale* (Fr.) Sing., I found that it had a bilateral trama (see *Ann. Myc.*, 34 : 330. 1936); later I found that *Biannularia* G. Beck was a synonym of *Catathelasma* Lovej., which also includes the American species *C. ventricosum*. Mature herbarium specimens of the latter showed regular trama (see *Rev. d. Mycol.*, loc. cit.). Fresh material sent to me from Maine in 1945 shows, however, strongly bilateral trama in young specimens, reminding one of the boletes; yet the strongly divergent lateral stratum as well as the mediostratum is pallid-hyaline, and the mediostratum is not pigmented.

The spores are (8)  $10-18.5 \times 4.2-5.5 \mu$ , amyloid, smooth, mostly

10–13.5  $\times$  4.8  $\mu$ ; a print was not obtained. The basidia are 4-spored, enormously long (50–68  $\times$  7.5–8  $\mu$ ). The subhymenium is ramose but its elements are very short; all hyphae are nonamyloid, with clamp connections, distant septa (except the subhymenium), and thin walls. I have not seen any cystidia of any kind.

KOH, NH<sub>4</sub>OH, formalin, and phenolaniline are all negative on the flesh as well as on the surface of the pileus. The taste and odor are the same as in fresh *Catathelasma imperiale*. Only the colors are different in these species. The pileus is ocher-pallid or brownish white with grayish patches (instead of much darker as in *C. imperiale*) and the annulate partial veil is ocher-pallid, not blackish fibrillose. The lamellae become pale grayish ochraceous in age, and they tend to separate from the flesh.

This is a gigantic fungus, at first glance reminding one of *Russula delicata*. It grows in northern coniferous woods. There is material preserved in alcohol from Castine, Maine, in the Farlow Herbarium, as well as dried materials from Pemaquid, Maine, and other localities. Only one specimen was determined as *Armillaria Laschii* Fr. by Farlow. The latter is undoubtedly, among all European species, the one that comes closest to *Catathelasma ventricosum* in appearance, but it is little known in Europe.

*Armillaria luteovirens* (Alb. & Schw. ex Fr.) Sacc.,  
Syll., 5: 75. 1887

This species has not been studied, thus far, very thoroughly. Since it belongs, however, to a unique type of some taxonomic interest, we shall add some hitherto neglected data which were obtained from material collected near Budapest, Hungary, by Moesz, in October, 1927 (FH).

Lamellulae abruptly rounded as in some species of *Leucopaxillus* and *Amanita*; trama of the lamellae consisting of a mediostratum flanked by a well-developed hymenopodium; the mediostratum subregular with interwoven broad (up to 12.5  $\mu$ ), rather short (comparatively) hyphae; the hymenopodium composed of parallel thinner (3.5–5.5  $\mu$ ) hyphae, not divergent in the stage the specimens had reached; subhymenium consisting of chains of very short hyphae, subcellular, its elements about 4.5  $\mu$  in diameter; no cystidia; basidia 27–34  $\times$  6–7.8  $\mu$ ; spores much like spores of *Amanita*,

smooth, short-ellipsoid, thin-walled, asymmetric, with no oil droplets or with from one to several oil droplets, without suprahilar depression, amyloid, not seen in print but perfectly hyaline,  $6-8 \times 4-5.5 \mu$ ; velar scales of the pileus consisting of hyphae which are almost radiately arranged but often more or less interwoven, some very short, smooth, hyaline, thin-walled, much like those of the mediostratum; cuticle proper of the pileus consisting of subparallel, thin-walled, hyaline hyphae, reminding one of the structure of the hymenopodium, these hyphae about  $2.5 \mu$  thick; all hyphae with clamp connections and nonamyloid.

*Observations.* — This species is generically different not only from *Tricholoma* and *Armillariella*, but also from genera more closely related to it, like *Leucopaxillus*. It has never been reported from America, but some other species have been described in this country which, according to their characters, may eventually enter the genus *Armillaria* as emended by me.

#### XVI. REDESCRIPTION OF *COLLYBIA IGNOBILIS*

##### *Collybia vulgaris* Sing. nom. nov.

*Collybia ignobilis* Karst. sensu auctorum Americanorum, non Karsten.  
*Gymnopilus ignobilis* Murr., North American Flora, 9 (5): 364. 1916.

Pileus grayish ochraceous, dirty brownish gray, horn-gray, "tilleul buff" (R.), even "vinaceous buff," hygrophanous, innately radiately fibrillose to almost homogeneous, paler when dry, short-striate on the margin when wet, or persistently astriate, glabrous, smooth, naked, nonviscid, convex with mostly umbilicate, or at least flatly depressed, center, 12-26 mm. broad. Lamellae pale creamy gray, almost pallid, broad, slightly and partially ventricose or applanate, rounded-adnexed, or adnate-subdecurrent, irregularly decurrent in very young specimens, somewhat eroded, later often wavy at the edge, medium distant to distant, with concolorous edge; spore print pure white. Stipe paler than the pileus, subconcolorous with the lamellae, often nearly pallid-whitish, narrowly tubulose, longitudinally innately fibrillose-silky when young, later quite glabrous and smooth, equal or subequal,  $20-40 \times 1.5-5 \mu$ ; mycelium white. Context concolorous with the surface, at least in the peripheric parts of the pileus and stipe, otherwise white or whitish; odor slight, farinaceous; taste farinaceous (and sometimes bitterish), slight.

Spores  $6.5-8.2 \times 4.8-5.3 \mu$ , mostly about  $7.6 \times 5.2 \mu$ , smooth, thin-walled, nonamyloid, sometimes with one oil droplet or without oil droplets, or frequently with numerous small oil droplets, many of them crowded near the wall and making it appear to be rough (but this is a refraction effect; the wall is never rough in Melzer's reagent, in which the oil drops disappear), almost ellipsoid; basidia  $24-35.7 \times 7.5-8.5 \mu$ , 4-spored, without carminophilous granulation; no cystidia or cheilocystidia; gill trama regular, consisting of parallel, filamentous hyphae; hyphae of cuticle radially arranged, filamentous, incrustated with a melleous pigment, all hyphae with clamp connections, thin-walled, nonamyloid.

*Chemical characters.* —  $\text{FeSO}_4$  reaction slowly and unequally gray, eventually grayish black.

*Habitat and distribution.* — In various habitats, e.g. on the ground in woods, under trees, on lawns and the like, on dry hills among mosses, and on wet ground as well, most frequently in frondose (but also in coniferous) woods among *Polytricha*; gregarious; fruiting from June until October. Extremely common in Massachusetts, reported from New York and Illinois; has not been noticed by me in northern Europe. (*Collybia ignobilis* Karst. is certainly not this plant!)

*Observations.* — *Collybia vulgaris* belongs in an interesting section of *Collybia*, one which (because of its colors, odor, and the variable attachment of the lamellae) was first regarded as belonging to *Clitocybe* rather than to *Collybia*. The collybioid habit, however, and the incrusting pigment are, among other characters, strong arguments in favor of *Collybia*. I therefore propose the following section:

### **Farinolentes Sing. sec. nov.**

Hyphae pigmento incrustatae, sordido, subgriseo, in pileo radially parallelae dispositae. Stipes glaber. Caro haud revivescens. Sporae in massa albae. Species typica: *Collybia vulgaris* Sing.

Other species that probably belong here are *Collybia clusilis* (Fr.) Gill. sensu Konr. & Maubl. (which differs in having larger spores) and perhaps what Lange calls *Clitocybe pachyphylla* Fr., unless it is a synonym of *Collybia clusilis*. This whole section has a characteristic reaction with  $\text{FeSO}_4$  which reminds one of the genus *Laccaria*.



XVII. A NEW SPECIES OF OMPHALINA IN THE ALPINE ZONE  
OF THE WHITE MOUNTAINS**Omphalina oreades** Sing. sp. nov.

Pileo spadiceo-fusco vel umbrino, hygrophano, pallide umbrino in statu sicco, margine dilutiore, pellucide striato in humidis, neque viscido neque vestito, at levi glabroque, convexo atque umbilicato vel exumbonato vel papillato, dein centro depresso, 3–10 mm. lato; cuticula paulum differentiata, ex hyphis filamentosis, repentibus vel vix ascendentibus, subirregulariter dispositis, interdum breviter cylindraceis vel claviformibus, pigmento fusco epimembranali in crustatis et ex ea re asperulatis efformata. Lamellis cremeo-griseolis vel flavido-umbrinellis, adnato-decurrentibus vel decurrentibus, arcuatis vel applanato-subhorizontalibus, maturis saepius profunde decurrentibus subarcuatisque, moderate latis (1–2 mm.) vel latis (2–2.5 mm.), distantibus vel eximie distantibus; sporis  $6.8\text{--}8.2 \times 3\text{--}7 \mu$ , levibus, haud amyloideis, guttula centrali globosula minore saepe praeditis, tenuitunicatis, bis oppositae curvatis (tildiformibus) vel parte hilari modo incurvata latus interius versus et ceterum ellipsoidalibus, hyalinis; basidiis  $22\text{--}24 \times 6.5\text{--}6.8 \mu$ , tetrasporis; cystidiis nullis; ad marginem pilei interdum cheilocystidia sparsa, parvula, inconspicua ( $16\text{--}27 \times 5\text{--}6.5 \mu$ ), ampullacea vel subcylindracea occurrunt; tramate ex hyphis cylindraceis vel allantoideis vel filiformibus irregulariter dispositis efformato, intermixto subregulari, inamyloideo. Stipite pileo concolori vel magis griseolo pallidioreque, pruinoso, glabrescente, aequali, curvato vel recto, farcto,  $10\text{--}12 \times 1\text{--}1.5$  mm.; velo nullo. Carne subconcolori superficiebus, inodora, miti; hyphis fibulis destitutis. In terra arenosa vel prope Polytricha ad fissuras rupestres solitario vel gregatim, Julio mense. In zona alpino-tundrica supra et ad limitem arborum in Mount Washington, White Mountains, New Hampshire, U. S. A.

*Observations.* — This species was collected by me in 1945 on two occasions. It is the only endemic species of the alpine zone of the White Mountains known thus far. The other species are all such as can stand the extreme climatic conditions of the Presidential Range, but are neither arctic nor alpine in distribution, belonging to the surrounding temperate-forest flora, which is holarctic-boreal or North American-Siberian or North American-boreal. The farther one descends into the valleys, the higher becomes the percentage

of American southern-temperate to subtropical species (such as *Amanita flavoconia*, *Russula compacta*, *Boletus rubellus* ssp. *bicolor*, and similar representatives of the moisture-loving flora of regions that are rather warm, at least in summer; these species abound in New England in the summer months, but are replaced by more boreal species in the fall). The only other species seen at as high an elevation on Mount Washington (5,200–6,260 feet) as *Omphalina oreades* were *Laccaria laccata* and *Deconica atrorufa*.

*Omphalina oreades* differs from other species of the section *Genuinae* Romagn. (i.e. the species without clamp connections, without differentiated cuticle, and without cheilocystidia or dermatocystidia, with white spore deposits, without carminophilous granulosity in the basidia, with nonamyloid smooth spores, with, often, incrusting pigment) in having a very peculiar kind of spore. *O. umbellifera* var. *abiigna* (B. & Br.), which is not uncommon in the subalpine zone of Mount Washington, differs in color, habitat, and spore shape; *O. philonotis* (Lasch) Quél., another circumboreal species, differs in size, color, habitat; and spore shape. Most of the remaining species of *Omphalia* (Fr.) Quél. sensu lato have clamp connections and belong either to the section *Fibulatae* Romagn. (*O. griseopallida*, *O. rustica*, *O. pyxidata*, and so on), or to *Clitocybe* (*C. hydrogramma*, *C. umbilicata*, and so on), or to *Mycena* (*M. swanetica*), or to *Marasmiellus* (*M. tricolor*, *M. fibula*, *M. crispulus*, *M. gracilis*, and so on), or to *Xeromphalina* (*O. campanella*), or to *Fayodia* (*F. bisphaerigera*, *F. maura*), or to other genera. *Omphalina* Quél. emend. Singer is closest to *Armillariella*.

### XVIII. TROPICAL SPECIES OF CALOCYBE

#### *Calocybe cyanella* Sing. sp. nov.

Pileo caeruleo ("dusky violet-blue" [R.], "nigrosin-blue," "dark madder-blue"), appresse subtomentoso, margine initio incurvo, levi, plano vel subdepresso in centro, c. 30 mm. lato; epicute ex hyphis subparallelo-subintertextis, filamentosis, repentibus, raro singulis ullis ascendentibus, sed locis quibusdam dispersis abbreviatis et in catenulas sphaerocystarum parvularum transeuntibus efformata; sphaerocystis illis 4–7  $\mu$  in diametro; hypodermio ex hyphis crassioribus, magis intertextis consistente et in carnem pilei transeunte, a qua pigmenti praesentia tantum differt; pigmento incrustante

membranas hyalinas sed partim in succo cellulari dissoluto, solubili in ammoniaco ( $\text{NH}_4\text{OH}$ ) et colorante alias hyphas in violaceum vel caeruleum. Lamellis albis, satis angustis, saepe sublaceratis, confertissimis, emarginato-rotundatis, attingentibus, an demum subdecurrentibus(?), lamellulis rotundatis neque attenuatis, marginem sterilem angustum relinquentibus ibique attenuatis; sporis in cumulo albis, sub microscopio hyalinis, nonamyloideis nec pseudoamyloideis, tenuitunicatis, levibus, ellipsoidalibus, guttula conspicua carentibus,  $4-5 \times 2.5-3.3 \mu$ ; basidiis clavatis, constanter tetrasporis, granulatione carminophila impletis distincta,  $18.5-22.5 \times 4.8-5.5 \mu$ ; cystidiis cheilocystidiisque conspicuis nullis, at aciebus nihilominus paene subheteromorphis e cheilocystidiis haud manifestis, centro ventricosis vel attenuatis, versiformibus, hyalinis,  $18 \times 4.5 \mu$ ; tramate lamellarum regulari, hyalino, haud amyloideo, ex hyphis tenuibus, subparallelis, magis intertextis, ubi contextum pilei et aciem approximant, consistente. Stipite caeruleo ("pale Windsor blue" [R.]) ad apicem, albo ad basin, glabro, aequali vel ad basin subattenuato, tomento basali albo,  $30 \times 3 \text{ mm}$ . Carne alba, carnosa, mediocriter crassa; sapore farinaceo et minime amarulo; odore farinaceo; hyphis omnibus fibuligeris, in carne fortiter intertextis et irregulariter dispositis, nonnullis membrana paulum incrassata instructis. In terra in dumetis tropicalibus solitario, Septembri mense. Florida, U. S. A.

*Chemical characters.* — Surface of the pileus unchanging with  $\text{NH}_4\text{OH}$ , aniline, and formalin, becoming purer and more dilutely blue with KOH; flesh not reacting with these reagents, but becoming slowly and not intensely positive (lilac) with methylparamidophenol, eventually turning almost black.

*Type specimen.* — Collected by me at Matheson Hammock, near Miami, Dade County, Florida, F-734 (FH).

*Observations.* — The genus *Calocybe* Kühn. is not uncommon in the American tropics. In Rick's collections from Brazil, sent to Farlow Herbarium without determinations, there are at least two more species, and Murrill described a *Collybia atroviolacea* (*Gymnopus atroviolaceus* Murr.) which belongs in *Calocybe*. Murrill's species, according to my study of the type (FLAS), is extremely similar to, and probably identical with, *Calocybe ionides* (Bull. ex Fr.) Kühner, but both of the Brazilian species are new.

**Calocybe rubra** Rick, in herb., sp. nov.

Pileo carneo-rubro, centro obscuriore, levi, sphaerocystis aegre visibilibus in superficie. Lamellis adnexis, polymacriis, angustis, confertissimis, concoloribus in siccis; sporis in cumulo haud visis, sub microscopio hyalinis, levibus, haud amyloideis nec pseudoamyloideis, ellipsoidalibus, tenuitunicatis,  $3.2-3.5 \times 2-2.5 \mu$ ; basidiis clavatis, tetrasporis, granulatione carminophila impletis distincta,  $13-17.5 \times 4.2-4.6 \mu$ ; cheilocystidiis versiformibus, in typo sparsis; tramate regulari, inamyloideo. Stipite concolori, albofarinaceo, 3 mm. crasso. Carne moderate crassa; hyphis omnibus fibuligeris. In ramentis arborum frondosarum. J. Rick, 585, 1928 (FH).

*Observations.* — Rick regarded this as a *Collybia*, but never published it. Its characters are sufficient to distinguish it, although better material, with more notes, is needed for certain data which are still lacking.

**Calocybe cyanea** Sing. sp. nov.

Pileo violaceo vel cyaneo vel coriaceo, saepe adiposo, centro atrovioleaceo vel subatro, in siccis plumbeo-griseo vel fusco-ardesiaceo (in typo "blackish brown [2]" Ridgwayi in centro et "deep brownish drab" vel "benzo brown" ad marginem, in collectione altera unicolori "Hathi gray" vel "deep neutral gray"), glabro, levi vel obiter rugoso, margine interdum undulato, e convexo expanso applanato, carnosulo, c. 30 mm. lato; epithelio epicuticulari bene evoluto, e sphaerocystis numerosis distinctissimis,  $5-25 \times 5-17.5 \mu$  consistente. Lamellis albis, in siccis iam albidis, linearibus vel sublinearibus, confertissimis, acie saepe erosis, adnexis; sporis hyalinis, breviter ellipsoidalibus, levibus, tenuitunicatis, minusculis,  $3.2-3.5 \times 2.3-3.2 \mu$ ; basidiis tetrasporis,  $14-20 \times 4.5-5 \mu$ , granulatione carminophila impletis; tramate regulari. Stipite pileo concolori, sursum et deorsum albido, striatulo, subaequali, subfirmo,  $30-35 \times 3-4$  mm. Carne molli vel sublenta; odore saporeque haud notatis; hyphis fibuligeris; neque hyphis nec sporis amyloideis. In ramulis stipitibusque delapsis in silvis. Porto Novo, prov. Sta Catharina, Brasilia. J. Rick, 1928 (FH).

*Observations.* — This species differs from *Calocybe rubra* in the color of the pileus, in the fact that the lamellae remain white when dried and perhaps, also, in the structure of the cuticle. The type

is the violet form with the dark center, but in view of the identity of the microscopical characters, I regard another of Rick's collections, which is now evenly gray, as a variety. This variety cannot at present be described under a separate name since the notes on the fresh fungus are insufficient. *C. cyanea* differs from *C. cyanella* in the structure of the epicutis and in having smaller spores.

The identity of Rick's *Clitocybe cyanea* could not with certainty be established, but considering the colors of the plant he describes, its occurrence in Brazil, and the variability in the form of attachment of the lamellae in *Calocybe*, it might be *Calocybe cyanea*. The spores would have been indicated incorrectly by Rick, if my suspicion regarding the identity of these species is justified, and the caespitose habit would be the only distinguishing character remaining between them. I have purposely chosen the same specific epithet in order to avoid a change if they should later prove identical.

#### XIX. A NEW AFRICAN SPECIES OF HYDROPUS

##### *Hydropus* (Kühner) Sing.<sup>4</sup>

Pileo cheilocystidiis latis, interdum sphaerocystoideis erectis, tenuitunicatis, demum ruptis tecto; pigmento tristi vel nullo; hyphis inamyloideis, fibuligeris; cheilocystidiis versiformibus, distinctis; sporis albis, breviter ellipsoideis vel ellipsoideis, levibus, amyloideis, in cumulo albis; lamellis variabiliter adnatis vel plus minusve decurrentibus. Habitu suo inter *Omphalinas* et *Collybias* intermedium genus. In lignis et in humo lignoso in zonis temperatis et tropicalibus. Typus generis: *Hydropus fuliginarius* (Batsch ex Fr.) Sing., *Mycologia*, 35: 160. 1943.

##### *Hydropus africanus* Sing. sp. nov.

Pileo fumoso ("smoke-gray" Ridgwayi), griseo-olivaceo-striato, breviter subsulcato, tomento squamisque destituto sed probabiliter pruinoso in statu vegeto, convexo vel subapplanato, in siccis umbilicato, 20–25 mm. lato; epicute e dermatocystidiis numerosis, erectis, subhyalinis, caducis, e.g.  $30 \times 11 \mu$  formata; hypodermio crasso,

<sup>4</sup> The section *Hydropus* Kühn. of *Mycena* has been taken over by me under a new status, that is, as a genus (*Mycologia*, 35: 160. 1943; *Lloydia*, 5: 129. 1942). Since Kühner has not given a Latin description of his new group, I supply it here.

brunneo-fusco, ex hyphis cylindrico-filamentosis repentibus efformato. Lamellis pallidioribus, subalbidulis, late adnatis vel subdecurrentibus, latissimis et saepe subventricosis, ad basin suam venose anastomosantibus, polydymis; sporis in cumulo albis, sub microscopio hyalinis, asymmetricis, globulosis vel subglobulosis, tenuitunicatis, levibus, membrana simplici, leniter sed distincte amyloidea instructis,  $6-7.7 \times 5-6.3 \mu$ ; basidiis granulatione carminophila destitutis, tetrasporis, c.  $30 \times 7 \mu$ ; cystidiis nullis; cheilocystidiis versiformibus, e.g. ampullaceis vel clavatis vel bis ventricosis, etc.,  $20-33 \times 3.5-7 \mu$ ; tramate subregulari, e cellulis elongatis, voluminosis, inamyloideis consistente. Stipite pileo concolori, subpruinato, tomento basali subdestituto, arrhizo, subaequali, subcartilagineo, tubuloso,  $22-30 \times 1-2$  mm. in siccis, pruina e dermatocystidiis eis pilei analogis sed saepe latioribus formata; hypodermio stipitis ex hyphis subcrasse tunicatis, parallelis, longitudinaliter dispositis consistente; hyphis omnibus fibuligeris. In lignis putridis. Firestone No. 3, Du River, Liberia, Africa, July 27, 1926. D. H. Linder, 130 (FH).

## XX. NOTES ON SOME SPECIES INTERMEDIATE BETWEEN MARASMIELLUS AND MARASMIUS

**Marasmiellus tricolor** (Alb. & Schw. ex Fr.) Sing. comb. nov. (*Agricus tricolor* A. & S. ex Fr., Syst. Myc., 1: 166. 1821); forma **americana** forma nov.

A forma typica lamellis tarde leniterque lutescentibus differt. In viis silvestribus gregatim aestate, Arlington, Massachusetts, U. S. A. R. Singer (FH).

Pileus pure white, later whitish, nonviscid, nonhygrophanous, subsulcate, convex-umbilicate, sometimes the margin eventually uplifted, always sulcate and crenate in age, sometimes with a tiny papilla in the umbilicus, the umbilicus eventually becoming slightly alutaceous, slightly adpressedly subfibrillose at first, later perfectly glabrous but unpolished, 5-12 mm. broad. Lamellae white, in many older specimens still whitish, in others becoming light orange or at least with an indistinct orange hue, distant, simple, entire, medium to rather broad, adnate-subdecurrent and subhorizontal, later decurrent and descendent; spore print white. Stipe white at

the apex, later becoming gray at the base, sometimes almost blackish below, opaque, subfibrillose to pruinose-subfibrillose, usually rather short, 0.5–1 mm. thick. Context white, tough in the stipe, elastic-soft but not fragile in the pileus, perfectly inodorous.

Spores  $10\text{--}11.5 \times 4.8\text{--}5\ \mu$ , hyaline, thin-walled, nonamyloid, fusoid-ellipsoid, with a globose central oil droplet, smooth; basidia  $35\text{--}42 \times 7\text{--}8\ \mu$ , 4-spored; basidioles cystidiform, fusoid; pseudo-paraphyses with large vacuoles, occasionally cystidiform, but real cystidia and well-differentiated cheilocystidia absent; epicuticular covering of pileus and stipe of the Rameales structure (echinate irregular bodies: "diverticulate," but not in palisade or forming an epithelium); all hyphae with clamp connections, nonamyloid.

*Observations.* — I have not studied the type, but, according to the description, I expect that *Marasmius vialis* Peck is the same form. Both grow along the forest paths on bare soil in summer, both are met with in the northeastern United States. There is not the slightest doubt that our form is conspecific with what is usually called *M. tricolor* or *Omphalia tricolor* in Europe. The spores are about the same size as those described by A. Ricken for *O. tricolor*, slightly smaller than those described by R. Kühner for his *M. tricolor* var. *sciodes*. They are much smaller than those in the closely related species *Marasmiellus caespitosus* (Pat.) Sing. comb. nov. (*Clitocybe caespitosa* Pat.) of North Africa, the type of which I have studied. Although Patouillard himself indicates that the spores of his species are much smaller, they are, when mature,  $12.5\text{--}19 \times 5\text{--}6.5\ \mu$ , mostly  $14\text{--}16.5\ \mu$  long, and the cystidia are lacking; the irregular nodulose and dendroid-branched hyphae of the epicutis of the pileus and stipe are nearly the same in *M. tricolor* and *M. caespitosus*. I have not personally studied specimens of *M. Trabutii* Mre. (1909), but it seems to me that there is very little to distinguish this species from *M. caespitosus* (Pat.) Sing. The variety with smaller spores later described by Maire is a counterpart of the small-spored form of *H. tricolor* described above.

According to Kühner's classification of *Marasmius*, these species would enter the section Rameales Kühn. In view of the transitional character of certain tropical species such as *Marasmiellus semiustus* (Berk. & Curt.) Sing. and of certain European (*M. candidus* (Bolt ex Fr.) Sing.) and Asiatic (*M. pseudoconidiophorus*) species between *Marasmius*, Rameales, and *Marasmiellus* (= *Hemimycena*) I pre-

fer to transfer the section Rameales to the genus *Marasmiellus*, including the following species: *M. ramealis* (Bull. ex Fr.) Sing. comb. nov. (*M. ramealis* (Bull. ex Fr.) Fr.); *M. anthocephalus* (Sacc.) Sing. comb. nov. (*M. anthocephalus* Sacc.); *M. rugulosus* (Berk. & Curt.) Sing. (*M. rugulosus* Berk. & Curt.); *M. nigripes* (Schw.) Sing. comb. nov. (*Helomyces nigripes* (Schw.) Morgan; *M. caesius* Murr.; *Gymnopus floridanus* Murr.<sup>5</sup>), and several other species not thoroughly studied by me. The section *Androsacei* Kühn. of *Marasmius* is closely allied with the rest of that genus.

## XXI. SUPPLEMENTARY DATA ON CRINIPELLIS AND CHAETOCALATHUS

*Crinipellis trichialis* (Lev.) Pat., Bull. Soc. Myc. Fr.,  
24: 8. 1908

In my monograph on *Crinipellis* and *Chaetocalathus* (*Lilloa*, 8: 511. 1942) I had to put this species among the "species incertae sedis." Additional material discovered in the Höhnelt Herbarium (FH) under *Lentinus* sp. *indet.* has furnished enough descriptive data, however, to make it possible to dispose of the species within the subdivisions of the genus *Crinipellis*.

*Crinipellis trichialis* is macroscopically characterized by an umbonate pileus with a strongly hairy center from which emerges a brushlike hood consisting of erect fascicles of hairs, which are comparable in color to those of *Lentinus crinitus* (the darker forms); the lamellae are whitish and medium broad. Höhnelt's material came from Buitenzorg, Java, and was collected on bamboo. Most of the hairs of the pileus are needle-like, often ladder-like at the apex, but a few are narrowed toward the apex and then suddenly rounded; they are golden melleous or (some) subhyaline; all are distinctly pseudoamyloid; they measure 5–9  $\mu$  in diameter, and the walls are 1.5–3.5  $\mu$  thick. The cheilocystidia are strongly incrustated with an amorphous resinous mass; they are numerous (edges of gills are heteromorphous) and measure 20–35  $\times$  5.5–8.3  $\mu$ ; a minority

<sup>5</sup> Not to be confused with *Marasmius floridanus* Murr., a common species of *Marasmius* of the warm zones of the Americas, and probably but a synonym of *M. fulviceps* Berk. I have studied the types of *Gymnopus floridanus* and *M. floridanus*, and of *M. caesius*, and also collected this well-characterized and common species in New York and Florida. It belongs to the *Rameales* group in spite of the unusual shape (angular) of its spores.



are entire or clavate, with sterigma-like clavulae at the apex, usually, however, with 2-4, rarely more, ramifications that branch off in the middle, or more commonly in the upper portion, of the cheilocystidium. The cystidia (pleurocystidia) are thick-walled or solid, opaque and refringent, mostly fusoid or narrowly clavate, hyaline, often with an appendage or a button-like tip, about as large or somewhat larger than the cheilocystidia, and numerous all over the sides of the lamellae. The spores are  $8.2-8.8 \times 5.5-5.8 \mu$ , the ones that remain on the lamellae or on the hairs after maturity has been reached often become still larger, reaching  $10.3 \times 6.8 \mu$ ; they are short-ellipsoid (quotient  $Q$  not less than 1.5), nonamyloid, thin-walled, unicellular in age, hyaline or eventually becoming yellowish-hyaline, and without suprahilar depression. The hyphae are hyaline, thin-walled, nonamyloid, with clamp connections.

The conclusion is that this species belongs in the section *Eucrinipellis*, subsection *Heteromorphinae*, together with the African species *Crinipellis minutula* (Henn.) Pat.

*Crinipellis minutula* (Henn.) Pat., Ess. tax. Hym.,  
p. 143. 1900

*Lentinus minutula* Henn., Engl. bot. Jahrb., 23: 547. 1897.

*Naucoria minutula* Pilát, Ann. Myc., 34: 123. 1936.

*Phaeomarasmium minutulus* Sing., Ann. Myc., 41: 151. 1943.

In my *Monographic Study of the Genera Crinipellis and Chaetocalathus* (Lilloa, loc. cit.) I adopted Patouillard's transfer of this species from *Lentinus* to *Crinipellis*, and made it the type species of a new subsection (see preceding species). This was done on the basis of the material preserved in the Patouillard Herbarium, which was sent to Patouillard by Hennings and which may now represent the last remaining authentic material of this species. The part of the type that was preserved at Berlin-Dahlem (now probably destroyed) was studied by Pilát, who described the spores as colored, very small, and somewhat verrucose. This description, together with that of the hairs of the pileus (rather correctly described by Pilát), caused me to consider the plant a species of *Phaeomarasmium* (this combination was made long before I had a chance to see the type and was entirely *vide* Pilát). Since the rest of Pilát's description fits our part of the type rather well, only the spores being different,

I am convinced that here we have a duplication of what happened with *Lentinus cubensis*, in treating which Pilát described mold spores as basidiospores, and that otherwise his and my material are identical. Consequently, my disposal of this species in *Lilloa* was correct, and the combinations in *Annales Mycologici*, 1936 and 1943, based on Pilát's error in the description or interpretation of the spores, should be disregarded.

*Chaetocalathus craterellus* (Dur. & Lév.) Sing., *Lilloa*,  
8: 518. 1842

On pages 517–520 of the monograph cited above, this species was referred to its correct position and redescribed. A few supplementary notes and the correction of two unfortunate printing errors will, however, help avoid possible misunderstandings about *Chaetocalathus craterellus*.

In the key, under A I, the manuscript should read: "Stipe rudiment distinct, button-shaped. No pseudoamyloid cystidia present." The description of *Chaetocalathus craterellus* says "cystidia none." This statement is correct. The description fails, however, to mention the existence of cheilocystidia, which are numerous on the heteromorphous edge of the lamellae. They are polymorphous, a majority usually being forked or having small ramifications in the upper portion, hyaline, without contents, nonpseudoamyloid, and rather thin-walled. The hairs of the pileus often reach  $7.5\ \mu$  in diameter. The spores were found to be  $7.5\text{--}8 \times 3.8\text{--}5.3\ \mu$  in other collections (which is in agreement with my description in *Lilloa*). The extension of the geographic area of this species to the tropics proper was in need of confirmation when my paper was written. Now I am in a position to assert the existence of *C. craterellus* in tropical Africa, for it was among material collected by G. W. Harley in Liberia. It differs from the Mediterranean materials merely in the lamellae being attached to the rudiment of the stipe, which is here rather small and, in some specimens, flattened to a mere disc, whereas in other carpophores it appears to be rather distinct. This tiny difference does not warrant the distinction of a tropical race or form. According to my present knowledge, *C. craterellus* occurs in the entire Mediterranean region, through the tropical belt of Africa, and along the western coast south to South Africa (if the latter

station is cited correctly by Pilát). This area is rather unique in mycology and can only be explained by a more detailed geobotanical investigation of the localities involved. The habitat in Liberia may possibly belong to the more xerophytic associations of that region.

The second error occurred in the same key. Line B II b was omitted by the printer. It should read: "b. Pileus not red."

## XXII. POSITION AND SYNONYMY OF *CLITOCYBE ILLUDENS*

### **Omphalotus olearius** (DC. ex Fr.) Sing. comb. nov.

*Agaricus olearius* DC. ex Fr., Syst. Myc., 1: 273. 1821.

*Pleurotus olearius* Gill., Hym. Fr., 1: 344. 1878.

*Agaricus illudens* Schw., Schrift. Naturf. Ges. Leipzig, 1: 82. 1822.

*Clitocybe illudens* Sacc., Syll., 5: 162. 1887.<sup>6</sup>

American material of the species described as *Clitocybe illudens* is specifically identical with European material known as *Pleurotus olearius*. Both species have abundant clamp connections and peculiar cystidia (two types), which are, perhaps, more properly described as pseudoparaphyses or cystidioles. One of these types occurs most frequently on and near the gill edges and originates from a basidium whose sterigmata (from one to several) take the shape of appendages, become much longer than usual, and fail to discharge spores; the upper part of the appendage is, however, occasionally separated from the "cystidium." In the other type of "cystidium," the lower portion is likewise basidiomorphous, but the apex is button-like, and it remains sterile; this "cystidium" is often found on the sides of the lamellae, also. The context turns cinnamon color (positive) with methylparamidophenol and is stained grayish by FeSO<sub>4</sub>. Other reagents (HNO<sub>3</sub>, KOH, NH<sub>4</sub>OH, aniline, formalin, and so on) cause no, or very little, change in color. The wall of many of the spores tends to become rather thick (though simple), a character reminiscent of *Armillariella*. The trama is rather irregular, without the slightest trace of bilaterality, and with a general trend toward an axillar arrangement; some of the hyphal walls are moderately thick.

All these data prove that the species belongs neither to *Clitocybe* nor to *Pleurotus*, and it cannot be regarded as a species of *Armill-*

<sup>6</sup> Additional synonyms are indicated by R. Maire (*Bull. Soc. Hist. Nat. Afr. Nord*, 7: 191. 1916) and by Konrad and Maublanc (*Icon. Selectae*, 6: 335. 1937).

lariella because of the absence of clamps in the latter genus. The general appearance, the luminescence, and the strong pigmentation make it outstanding enough to warrant separation into an autonomous genus, as was suggested by Fayod fifty-seven years ago. Since Fayod did not actually make the combination *Omphalotus olearius*, I propose it here as the valid name of this species.

### XXIII. TWO NEW SPECIES OF THE PLEUROTOIDEAE

#### **Pleurotus floridanus** Sing. sp. nov.

Pileo albo vel centro pallide alutaceo, subtiliter villosulo vel subglabro, levi vel sublevi et ad marginem haud sulcato, convexo, dein irregulariter concavo, statu intermedio subplano saepe observato, mox infundibuliformi, 30–75 mm. lato. Lamellis albis in vegetis, confertissimis, angustissimis (1 mm. latis), integris ad aciem, profunde decurrentibus; sporis albis, sub microscopio hyalinis, levibus, haud amyloideis, ellipsoideis vel subcylindraceutis,  $4-5 \times 2-2.8 \mu$ ; basidiis tetrasporis,  $20 \times 4-4.8 \mu$ ; cystidiis numerosis, crassitunicatis vel ad apicem solidis, crystallino-capitatis in compluribus, fusoido-ampullaceis vel ventricosus-capitatis, fortiter ventricosus in centro,  $20-25 \mu$  projicientibus, apice obtuso instructis, haud pseudoamyloideis, membrana  $0.7-4 \mu$  crassa, plerumque plus  $1 \mu$ , saepe  $1-2 \mu$  crassa, hyalina praeditis,  $31-56 \times 8-13.5 \mu$ ; tramate ex hyphis hyalinis, intertextis, tenuissimis, membranis subincrassatis instructis efformato, haud amyloideo; subhymenio lato, distincto. Stipite albo, demum pallide brunneolo, subtiliter villosulo, basin versus subattenuato vel irregulari, saepe ramuloso, solido, saepe conrescente,  $14-40 \times 3-10$  mm.; tomento basali fibrilloso, ex hyphis filamentosis, fibulatis consistente, hyphis terminalibus saepe clavatis atque usque ad  $7 \mu$  latis. In truncis frondosis (indeterminatis, vetustis). Highlands Hammock State Park, Highlands County, Florida, U. S. A. R. Singer, F-217 (FH).

*Observations.* — This species differs from the known species of *Panus* in being white and in having a distinct subhymenium. Other white species of *Pleurotus* lack the characteristic cystidia.

#### **Resupinatus chilensis** Sing. sp. nov.

Pileo in siccis griseolo, sub lente tomentosulo, dimidio externo sulcato, resupinato, anguste campanulato, pendulo, base attenuata

adnexo, margine primum incurvato, dein obtuso, 1-2 mm. lato; cuticula consistente ex hyphis jacentibus, intertextis, densis neque gelatinosis, indistinctis incrustationis causa, saepe ramulos breves emittentibus, ad aciem lamellarum de margine pilei transeuntibus. Lamellis pallidioribus, venosis, acie obtusis, ad marginem tomentosis, ascendentibus, radiantibus, angustissimis, subanastomosantibus, distantibus (interdum una vel tribus tantum), parte sua interiore approximantibus sese ita ut hymenophorum frequenter porosum (Favolaschiarum modo) videatur; sporis  $6.3-7.5 \times 4.2-6.3 \mu$ , regulariter breviterque ellipsoideis, hyalinis, levibus, inamyloideis, tenuitunicatis; basidiis  $28-29 \times 6.3-7 \mu$ ; corpusculis sterilibus in hymenio nullis, sed cheilocystidiis indistinctis pseudophysoideis observatis; tramate ex hyphis hyalinis, irregulariter undulosis in massa gelatinosa, tenuibus, haud amyloideis, fibulatis consistente. Carne exigua. In lignis mortuis; admodum gregatim. Prope Punta Arenas, Chile. R. Thaxter (FH).

*Observations.* — This species differs from most other species of the genus *Resupinatus* (= *Scytinopsis* Sing.) in the strange, narrowly bell-shaped carpophores and the narrow distant lamellae.

#### XXIV. TRAMAL STRUCTURE AND TAXONOMIC POSITION OF TERMITOMYCES HEIM

*Termitomyces eurhizus* (Berk.) Heim, Arch. Mus. Nat.  
Hist. Natur., VI, 18: 140. 1943

*Rajapa eurhiza* (Berk.) Sing., Lloydia, 8: 143. 1945.

Additional material that has come to my attention shows clearly the bilateral hymenophoral trama. The material consists in part of well-preserved young caps gathered in Indo-China; older specimens of the same collection show the trama exactly as described by me (*loc. cit.*), i.e. regular. The mediostratum is composed of parallel, densely packed, and rather thin clampless hyphae; the lateral stratum consists of less straight, less densely arranged hyphae, curved and divergent from the mediostratum toward the hymenium. All these specimens are ringless, and it is probable that the specimens sent to Patouillard by Petch (FH), with distinct annulus and heavier, larger carpophores, are, though certainly closely related, nevertheless specifically different (*Agaricus albuminosus* Berk.).

The trama found in these specimens from tropical Asia is com-

parable to the trama of *Limacella* (where, however, the septa are clamped), rather than to that of *Pluteus* and *Volvaria*. This assures the genus autonomy even among the *Amanitaceae*, if it should be transferred there on the basis of the tramal anatomy.

War conditions made it impossible to keep informed of papers appearing abroad, and I have unfortunately published a new generic name (*Rajapa*) for a genus already described by Roger Heim. Nonetheless, the fact that both Heim and I, starting from entirely different material and different experiences, have come to practically the same result independently, viz., the erection of an autonomous genus for species of the type *Termitomyces eurhizus*, and the like, is in itself very satisfactory. We now have one more unnecessary synonym, but we also have conclusive proof that two authors, who sometimes differ on minor matters of taxonomy or in problems of theory, but both of whom use the methods of modern mycological taxonomy, will arrive at the same solution in systematics if all factual observations are correctly made.

As for Heim's work, I refer the reader to the following publications (1940-43):

1. Culture artificielle des mycotètes . . . . Comp. r. Acad. Sci., 210: 410-412. 1940.
2. Études descriptives et expérimentales sur les agarics termitophiles d'Afrique tropicale. Acad. Sci. Inst. France Mem., 64: 1-74, pls. I-X. 1941.
3. Les *Termitomyces* dans leurs rapports avec les termites prétendus champignonnistes. Comp. r. Acad. Sci., 213: 146-148. 1941.
4. Les Champignons des termitières. Rev. Scient., 80 (3205): 69-86. 1942.
5. Nouvelles études descriptives sur les agarics termitophiles d'Afrique tropicale. Arch. Mus. Nat. Hist. Natur., 18: 107-166. 1943.

***Termitomyces LeTestui* (Pat.) Heim, Arch. Mus. Nat.  
Hist. Natur., VI, 18: 109. 1943**

The type of this species is preserved at the Farlow Herbarium. Since the tramal structure was not known, I compared the part of the type marked "état jeune" — all three collections are identical, by the way, even the "forme sans anneau" — and found the trama bilateral, with axillary arranged interwoven hyphae composing the mediostratum and looser, more hyaline, curved-divergent hyphae forming the lateral stratum. All these hyphae are rather thin, filamentous, and nonamyloid, devoid of clamps.

The data above show that in the deep-colored, large species of the

African *Termitomyces* the trama is bilateral, just as in the Asiatic species. They also show that Heim was right in his delimitation of the genus. We may now conclude that the trama is bilateral (not reversed) in young specimens of *Termitomyces* and that it later becomes regular in this genus, the trama being a constant generic character here as elsewhere. The persistent absence of clamp connections in all species of *Termitomyces* gives additional evidence of the value of this particular character, whose importance has been emphasized by me in several previous papers (see *Lloydia*, 5:98. 1942).

***Termitomyces congolensis* (Beeli) Sing. comb. nov.**

*Lepiota congolensis* Beeli, Bull. Soc. R. Bot., B.: 109. 1927.

Material has been received from Liberia (G. W. Harley, 21 [FH]) that is identical in all characters with *Lepiota congolensis* Beeli. I have compared this material with *Termitomyces LeTestui*, which differs strongly in appearance, especially in the rugose surface and the peculiar shape of the pileus; yet these species are evidently very close to each other. It is remarkable that neither Beeli nor Harley mentions termites at all, but we agree with Heim that the long pseudorhiza obviously leads down to termite nests, which are invisible from above to the unsuspecting collector.

XXV. CHLOROPHYLLUM MASS. AND MACROLEPIOTA SING.

*Chlorophyllum molybdites* (Mey.) Mass., Kew Bull.,  
p. 136. 1898

*Agaricus molybdites* G. Meyer, F. Essequ., p. 300. 1818, ex Fries, Epicr., p. 13. 1836.

*Agaricus Morgani* Peck, Bot. Gaz., 4: 137. 1879.

The following description is the result of studies on fresh material I collected in Florida and compared with the type specimen of *Agaricus Morgani* Peck. I do not know whether there is a type specimen of *A. molybdites*, but it seems to be the general agreement that this species, very common in the American tropics, is the one that Meyer described.

Pileus buffy white (rarely pinkish when still smooth and closed), beset with minute fibrillose to flocculose scales, which are deterrent

and brownish, more so on the margin, but eventually often glabrescent, the disc covered by a "wood-brown" (R.) to "mummy-brown" cortex, which breaks up sooner or later centripetally into semi-erect, irregular, brown scales, not sulcate or with rather indistinct, very short furrows on the margin of the oldest specimens, dry, campanulate with broadly rounded top, then convex to conic-convex or globose-convex, then flatter, frequently with a distinct umbo, 47-190 mm. broad. Lamellae glaucous-pallid, soon becoming "tea-green" (R.) to "dark glaucous gray," sometimes staining reddish or brownish when injured, remote-free, moderately broad (up to 10 mm. broad), close to crowded; spore print in the color of the lamellae or "bice-green," "deep grape-green," "grape-green," "pois-green." Stipe pure white to whitish pallid, eventually with brownish stripes or uniformly brownish, glabrous, naked, annulate, solid, then stuffed, then with loose cottony stuffing in the hollow (as in *Coprinus comatus*), tapering upward or equal, but bulbous below,  $70-200 \times 10-14$  mm., the bulb 11-35 mm. in diameter; annulus concolorous with the stipe, or the central layer brownish at the margin, with a triple border, of the structure of an annulus of the Proceri group, initially fixed, but by shrinking becoming movable, free, and often sliding down the stipe. Context white, reddening on injury or remaining unchanged, especially in dry weather and in old specimens, and then the apex of the pileus "buckthorn-brown" inside and the context of the cortex of the stipe more or less brownish; odor very agreeable, of perfume or fruit, even in dried material; taste mild.

Spores  $10.2-13 \times 6.8-8.8 \mu$ , hyaline to greenish hyaline, smooth, with thick, triple wall and distinct germ pore, the wall pseudoamylloid, in many spores the exosporium separated from the endosporium by an intermembranal layer or space that often appears to be pink in KOH-phloxine, the entire spore, including the endosporium, becoming bright and deep blue if dyed with neutral brilliant cresyl blue, the metachromatism of the wall either absent or obscured by the strong absorption of the blue by the spore; basidia about  $42 \mu$  long,  $11.5-12.5 \mu$  broad, 4-spored; cheilocystidia versiform (often clavate),  $40-60 \times 10-16.5 \mu$ ; trama subregular, of cylindric-filamentose hyaline or greenish-hyaline nondivergent hyphae; the context of the stipe deeply entering that of the pileus and distinctly separate from the latter in sections; the brown cortex of the disc consisting of strongly interwoven or semierect to repent strands of parallel



agglutinated brownish hyphae, often partially intermixed because of the larger diameter of many hyphae, some hyphae with slightly thickened walls, most of them rather thin; annulus consisting of rather parallel, rather dense, hyaline, thin-walled hyphae, on its surface some velo-cystidia which are mostly clavate,  $23-35 \times 10-12 \mu$ ; all hyphae nonamyloid, without clamp connections.

*Chemical characters.* — Methylparamidophenol reaction on the context negative at first, eventually turning it brown, more so in the stipe, less so in the pileus, even the spore print browning with this reagent.

*Habitat.* — On lawns, in plantations, in open woods and parks under various trees, on improved garden earth, in ruderal places, on sandy soil even though containing some salt, occasionally in abandoned gardens overgrown with second-growth tropical hammock, on the ground; gregarious; fruiting from April until November in the Northern Hemisphere, fruiting in winter in the Southern Hemisphere.

*Distribution.* — Probably pantropical, in America reaching deep into the temperate zone (north to New York and Michigan), in Europe only in greenhouses; most abundant in America and Oceania.

*Florida material studied.* — Dade County, Fairchild Tropical Garden, R. Singer, F-1376 (FH), Brickell Hammock, R. Singer, F-1376a (FH); Highlands County, Highlands Hammock State Park, A. Altvater, F-86 (FH); Alachua County, Gainesville, W. A. Murrill and R. Singer, F-86a (FH), R. Singer, F-86b, F-1953 (FH).

### Var. *luteolosperma* Sing. var. nov.

A typo sporis in cumulo luteolis recedit.

*Observations.* — This variety (type from Gainesville, Alachua County, Florida, R. Singer, F-1953a [FH]) differs in the "deep colonial buff" (R.) spore print and lamellae; the context tends to become reddish as well as yellow on injury. It grows solitary at the type locality.

Kühner (*Comp. r. Acad. Sci.*, 198:843 (1). 1934) indicates an interesting metachromatism in the spore preparations of *Lepidta procera* that were dyed with cresyl-blue. I checked on this character not only in *L. procera* but in most other species of the Proceri group, including such species as *L. Badhamii* and *L. naucina*, and always

found the pinkish to pale lilac-pink endosporium contrasting with the violet-pallid exosporium. All the species of *Hiatula* (sensu Heim and Romagnesi) show the same metachromatism. None of the species of *Lepiota* sensu stricto which I have checked (*L. clypeolaria*, *L. clavipes* Henn., *L. acutesquamosa*, and so on) showed this metachromatism, the endosporium either appearing in the same shade as the exosporium or not developed at all. In a series of recent papers Locquin reunites the groups having spores that can be dyed metachromatically with cresyl-blue and having thick walls and a germ pore under the common name *Leucocoprinus* Pat. He thinks, as I do, however, that the groups making up this supergenus are eventually to be regarded as its generic elements — although he now treats them as subgenera. This treatment, though in my opinion taxonomically sound, is untenable from a nomenclatorial point of view, since Patouillard based his genus on a species of the *Hiatula* type (but annulate), and if *Hiatula* is included in the same genus as *Lepiota procera*, one has to use the older generic name “*Hiatula*” instead of “*Leucocoprinus* Pat.” If, however, *Hiatula* and the other subgenera are considered independent genera, it is obvious that the *Proceri* group remains without a generic name, unless *Chlorophyllum* can be considered to be congeneric with it. Patouillard, Heim, and I (1943) were inclined to think that *Chlorophyllum* is congeneric with the *Proceri* group, whereas Massee, Murrill, and others admitted *Chlorophyllum* in addition to the genus containing the *Proceri* group.

In the light of the description of *Chlorophyllum molybdites* above, I am now inclined to believe that *Chlorophyllum* should be generically separated from the *Proceri* group. The structure (the intermembranal space), color (green or colonial buff) and susceptibility to dye (brilliant cresyl-blue coloring the whole spore uniformly deep blue, like the gloecystidia of the *Aphyllphorales*), the presence of a rather violent poisoning matter, and the absence of clamp connections put this species in obvious contrast to the *Proceri* group. So long as these characters were either unknown or not considered to play an important rôle in the taxonomy of the *Leucocoprinaceae*, we were entitled to regard *C. molybdites* and *Lepiota procera* as congeneric. Now we must separate them, in spite of the external similarity of the carpophores. We cannot, however, exclude *Chlorophyllum* schematically from the group *Leucocoprinus* sensu Locquin merely

on the basis of the action of the dye. On the contrary, I propose to include *Chlorophyllum* Mass., together with the *Proceri* group, *Clarkeinda* Kuntze (= *Chitoniella* Henn.), *Schinzinia* Fayod, and possibly some of the new subgenera published by Locquin, in the same tribus, which I propose to call:

**Leucocoprineae** trib. nov.

Sporis pseudoamyloideis, crasse tunicatis, membrana duplici (vel triplici), poro germinativo plus minusve distincte interrupta, tinctura cresyllo-cyanea ("brilliant cresyl-blue") metachromatice tinctis (raro monochromatice tinctis et tunc in cumulo viridibus vel alutaceis); annulo saepe mobili, frequenter multistratoso, aut pileo ad marginem plicato-sulcato. Genus typicum:

**Macrolepiota** Sing. gen. nov.

Sporis majusculis vel giganteis, membrana metachromatice tincta tinctura cresyllo-cyanea, in cumulo albis vel cremeis (vel roseis?); hyphis fibuligeris. Species typica: **Macrolepiota procera** (Scop. ex Fr.) Sing. comb. nov. (= *Lepiota procera* auctor.).

*Observations.* — The tribus *Leucocoprineae* is here distinguished from the tribus *Lepioteae* (genus *Lepiota* S. F. Gray sensu stricto and perhaps *Pseudobacospora* Sing. and *Schulzeria* Bres.) and also from one or two more tribes to be described for the genera *Cystoderma* Fay., *Smithiomyces* Sing., and *Drosella* Maire.

STROPHARIACEAE

XXVI. REDESCRIPTION OF *DECONICA CROBULA* FROM AMERICA

**Deconica crobula** (Fr.) Romagnesi, Rev. d. Myc., 2: 244. 1937 (sensu Lange, Fl. Ag. Dan., 4: 28. 1939)

*Tubaria crobula* (Fr.) Sacc., Syll., 5: 876. 1887.

Pileus "Rood's brown" (R.), strongly hygrophanous, opimous-subviscid, not glutinous, smooth, very minutely and indistinctly striatulate by transparence on the margin, convex to flat, with a small umbo, 8–14 mm. broad. Lamellae between "avellaneous" and "wood-brown," paler-fringed, moderately broad for a *Deconica* but actually rather broad, broadly adnate but not at all decurrent,

moderately close or subclose; spore print bister-sepia. Stipe concolorous with the pileus or paler at the apex, much deeper colored (bay-fuscous) at the base, but almost entirely covered with fibrillose squamules derived from the veil, leaving only a small part of the apex naked, subequal or equal,  $14-32 \times 1-1.5$  mm.; veil white on the stipe, initially also very strongly developed on the margin of the pileus, where it forms silky, detersible, appressed fibrils which often agglutinate to form pure-white, irregularly distributed small flocci; a well-formed annulus usually wanting. Context paler, in the stipe rather deep brown; odor and taste not remarkable.

Spores  $5-6.7 \times 4.2-5.5$   $\mu$  when seen frontally, narrower when seen in profile ( $3.3-4.2$   $\mu$ ), lentiform, but not distinctly rhomboidal, with a fuliginous tint, smooth, with double wall and wide flat germ pore; cheilocystidia  $27-38 \times 5-5.5$   $\mu$ , with a ventricose lower portion and a long filiform apex, which is  $2-2.5$   $\mu$  broad and obtuse; epicutis composed of repent, filamentous, hyaline hyphae with clamp connections.

*Observations.* — This species was found on logs under *Carya*, gregarious, June 24, 1945 (R. Singer and H. Dadmun [FH]), at Harvard, Mass. Except for being very slightly larger, the species coincides in all important characters with the species described as *Tubaria crobula* by Lange. The plant described as *Deconica crobula* by Romagnesi differs markedly in a few characters and is probably identical with what some authors consider the lignicolous form of *D. inquilina*, whose typical form (in our conception) is graminicolous. It may be that the grass form should be called *D. ecbola* (Fr.); Romagnesi's form may be called *D. inquilina*, and the form described above, *D. crobula*. These observations are not intended to anticipate anything so far as the proper interpretation of the Friesian species goes. This must be left to the monographer.

Another common species of *Deconica* in New England is *D. atrorufa* (Batsch ex Fr.) Sacc. (which may be the same as *Psilocybe polytrichicola* Peck).

## XXVII. A NEW SPECIES OF PHOLIOTA

### *Pholiota Maackiae* Sing. sp. nov.

Pileo centrum versus sordide brunneolo-ochraceo, ad marginem aeruginascente, squamis punctiformibus in disco asperso demum ni-

grescentibus et spiniformibus, pellicula viscida praedito, in siccis nitente, veli vestigiis ad marginem visibilibus, convexo, magnitudine mediocri. Lamellis olivascente-argillaceo-brunneis, aciebus flavis, latissimis, subconfertis, late adnexis, partim subdecurrentibus-subsinuosis; sporis  $5-7.7 (8.8) \times 4.5 (5) \mu$ , poro germinativo indistincto inconstanteque praeditis, levibus, ochraceo-brunneolis, paucis obscure brunneis; basidiis  $20 \times 6.6 \mu$ ; cystidiis et cheilocystidiis praesentibus, ampullaceis, ad basin in stipitem  $5-10 \mu$  longum attenuatis, parte media ventricosis,  $9-11.5 (25) \mu$  latis, apice  $5-6.6 \mu$  latis, raro subcapitulatis,  $35-53.5 \mu$  longis, tenuitunicatis, hyalinis, pleurocystidiis tantum vivide luteis et lucem fortiter refringentibus; acie heteromorpha. Stipite pallide flavido, ferrugineo-ochraceo ad basin, annulo subcaduco, subtili, ascendente-distante, fibrilloso, mediano instructo, squamis destituto, ad apicem attenuato vel base subincrassato, longitudinaliter compresso et subexcentrico, curvato, magnitudine *Pholiotam luciferam* aemulante. Carne sicca pallide luteola. In trunco *Maackiae amurensis*, Septembri mense 15, 1939, Coll. Lyubarski in regione Khabarovskensi. The type locality is in the U.S.S.R., Far Eastern region, Khabarovsk kray; sixty-nine km. from the branching of the Oborski L. P. Kh. R.R. The type is preserved in Leningrad; cotype material is probably available at Khabarovsk.

## CORTINARIACEAE

XXVIII. REDESCRIPTION AND TRANSFER OF *PHOLIOTA**CONFRAGOSA****Naucoria confragosa* (Fr.) Sing. comb. nov.**

*Pholiota confragosa* (Fr.) Karst., Hattsv., p. 304. 1879.

Pileus flesh-color-cinnamon, cinnamon-rufous, subglabrous to inately scurfy-fibrillose, hygrophanous, pale buff or a very pale cinnamon-buff when dry, with striate margin which becomes smooth when dry, nonviscid, convex-umbilicate, 26-50 mm. broad. Lamellae pale rufous to cinnamon, with a slight olive-cinnamon tinge, nearly burnt ocher when old and dry, with slightly fimbriate, pallid edge, flatly adnate, narrow (up to, and usually as much as, 3 mm. broad), subclose to close; spore print dirty ferruginous burnt ocher (Séguy, No. 336). Stipe carneous-brownish white at the apex and merely subsericellous there, gradually darker below the annulus,

reaching a shade similar to the color of the pileus, covered with pale carneous-brownish or pale pinkish-cinnamon squamulae up to the annulus, on whose lower side they may form a definite zonation by leaving the outer margin of the annulus naked, but not always clearly delimited, white-tomentose at the very base; stuffed, then hollow, reaching 10 mm. at the base and tapering to the apex, where it is up to 5 mm. broad, up to 80 mm. long; annulus at first distant, horizontal to suberect, later partly or entirely pendulous, rarely evanescent, striatulate above, carneous-brownish-pallid, superior. Context hygrophanous, subconcolorous with the surfaces, almost reddish when dry; odor lacking; taste mild.

Spores bean-shaped, frontally egg-shaped, with the longitudinal sides often almost plane (straight) and the ends rounded,  $7-8.5 \times 4-5.8 \mu$ , smooth, pale ferruginous, with one large or several small oil droplets, the wall indistinctly double but moderately thick, without a distinct germ pore; basidia  $21-23.5 \times 5-6 \mu$ , 4-spored; cheilocystidia  $45-70 \times 8-8.5 \mu$ , at the apex  $3-4 \mu$  thick, hyaline, usually subulate-elongate, with thin to slightly thickened ( $0.8 \mu$ ) wall, with obtusely rounded, rarely somewhat capitate, apex, borne on subisodiametric cells; cystidia lacking; edges of gills heteromorphic; subhymenium cellular; trama regular, consisting of hyphae up to  $9 \mu$  in diameter; epicutis of the pileus composed of a palisade of crowded erect dermatocystidia; these dermatocystidia bearing a terminal member that is often similar in shape to the cheilocystidia (with which they are homologous), or more cylindric, usually with rounded tips,  $23-35(66) \times (10) 11-15 \mu$ , rarely as elongated as  $66 \times 10 \mu$ , rarely mucronate, walls more or less thickened ( $1-1.7 \mu$  in diameter), pigment-incrusted (brown), otherwise hyaline; hypodermium consisting of filamentous hyphae which are occasionally rough, always repent, brownish; annulus consisting of filamentous hyphae, some of them rough; all hyphae with clamp connections. KOH on the pileus causing immediate blackish-brown discoloration.

*Habitat.* — On old or very decayed stumps (*Fagus*, *Betula*, *Picea*) and on scattered sticks and débris on the ground in open mixed woods, caespitose to (sometimes) subfasciculate, more rarely some individuals growing singly, fruiting from July to September.

*Distribution.* — Most of northern England, Scandinavia, Finland, Leningrad region and east to Siberia; much rarer in Central Europe (mostly in the montane zone, especially in the Alps and the

Carpathians); also in the northeastern United States (New York and the New England states), and probably in Canada; the western limits unknown.

*Observations.* — This is not a species of *Gymnopilus* (neither is it, of course, a species of *Pholiota*) or of *Fulvidula*, as has been suggested by me previously (*Rev. d. Myc.*, 2: 239. 1937), but, as the description above immediately suggests, a large annulate species of *Naucoria* (Fr.) Quél. I accept, as in my previous papers, the genus *Naucoria* in the sense in which it has been restricted by me, i.e. with *N. centunculus* and closely related species included, all other species referred to other genera (*Galerina*, *Agrocybe*, *Alnicola*, *Phaeocollybia*, *Phaeomarasmus*, and so on).

The description above is based on material collected by the writer in the Leningrad region and in the Karelo-Finnish Republic, also in Tyrol (Austria) and other places.

## XXIX. TWO NEW CORTINARIACEAE

### *Tubaria thermophila* Sing. sp. nov.

Pileo lateritio-badio-spadiceo, colore primum *Leucopaxillum amarum* fere in mentem revocante, dein cinnamomeo-brunneo vel ferrugineo-brunneo (squamulis vel fibrillis marginis "Mikado brown" Ridgwayi, centri "amber-brown"), dense tomentoso, mox in squamulas fracto, squamulis confertissimis, minutis, subfibrillosis ad marginem, ad centrum distinctioribus, cuticula saepe subrimulosa ad marginem extremum instructo, convexulo-planiusculo, dein plano, demum concavo, 22–30 mm. lato; cuticula ex hyphis repentibus, jacentibus, irregularibus, fibuligeris, saepe pigmentatis pigmento epicellulari (intercellulari), amorpho et intracellulari, dissoluto, nonnullis guttulis impletis gloecystidiorum modo consistente. Lamellis albido-gilvis vel albidis, dein sordide argillaceis vel pallidissime griseo-incarnatis, sinuato-decurrentibus vel fortiter decurrentibus, subangustis, confertis vel confertissimis; sporis dilute sed laete ferrugineis, verruculosus, disco suprahilari levi nullq, breviter fusoides, centro crassissimis, ad apicem angustatis, depressione supra-hilari notata,  $8-9 \times 6-6.5 \mu$ ; basidiis clavatis (1) 2-sporis,  $13.5-23 \times 7.5-8.5 \mu$ ; cystidiis nullis; cheilocystidiis hyalinis, versiformibus, pleurumque clavatis vel subclavatis, nonnullis subfusoides, apicem versus angustatis vel late rotundatis, nonnullis interdum digiti-

formiter appendiculatis digitis uno vel duobus, nonnullis semierectis vel ascendentibus vel agglutinatis; subhymenio e cellulis brevissimis parvulis consistente; tramate lamellarum hyalino, subregulari. Stipite albo, raro in parte subcitrinello, glabro, nitente, solido, subaequali vel base subincrassata praedito,  $29-68 \times 2-4$  mm.; velo haud manifesto. Carne albida, inodora, miti; hyphis fibuligeris. In dumetis subtropicalibus humidissimis in terra humoso-sabulosa vel nonnunquam nucibus *Caryae megacarpae* affixi vel e ligno mucido ecescentes, aestate. Highlands Hammock State Park, Florida, U. S. A. R. Singer, F-20, F-20a (FH).

*Galerina hypnorum* (Schrank ex Fr.) Kühner var.  
*evelata* Sing. var. nov.

A forma typica sporis calyptratis, colore intensiore laetioresque, veli absentia differt; a forma *calyptrospora* Kühn. absentia veli coloreque differt.

Pileus ochraceous-fulvous, hygrophanous, drying from the top downward, more than half the radius transparently striate, smooth and pale ochraceous or alutaceous-pallid when dry, not viscid, glabrous, at first subcampanulate, obtuse, later conico-convex, about 5 mm. broad when mature. Lamellae ochraceous, rather distant, at first adnate, subascendant, later adnexed to adnate, subhorizontal. Stipe subconcolorous with the pileus, smooth, glabrous, filiform, variable in length, about 1 mm. thick; veil lacking even in young specimens. Context very thin, subinodorous.

Spores  $11-13.5 \times 6.8-8.2$   $\mu$ , with a saccate perisporium; cheilocystidia  $40-50 \times 11-13.7$   $\mu$ , ampullaceous, with strongly ventricose base (as in *Galera cerina* Bres.) and with a cylindric or pencil-shaped apex, rarely capitate or obtusely conic, apex  $6.7-8.2$   $\mu$  in diameter; basidia 4-spored; hyphae with clamp connections.

*Observations.* — The type of this variety is one of the specimens collected by the writer on Mount Washington between 5,000 and 5,500 ft., i.e. in the subalpine zone of the White Mountains, New Hampshire (WM-3, WM-21, FH), under rather severe climatic conditions (strong winds and low temperatures, but with sufficient moisture during most of the year), in August, 1945. Other specimens that may be referred here were collected in the Altai Mountains (R. Singer, A-765 [LE]), under similar climatic conditions,



near Lake Teletskoe, Oirotia, in August, 1937. It is characteristic that farther south and at a lower altitude in New England (e.g. in Massachusetts) — even later in the fall — the type variety of *Galerina hypnorum* is observed, a form agreeing well with Kühner's description and the writer's notes on the bisporous form of the European type.<sup>7</sup> Furthermore, the specimens from the dry habitats of the Kosh Agatch valley in the Altai Mountains proved to be different from var. *evelata*. Additional observation of the young specimens as regards the color of their pileus and the correlation of the occurrence of a perisporium should show whether this is an adaptation to cold and not-too-dry habitats in the mountains or a definite geographic race, or perhaps an independent species.

It is possible that *Galerula subhypnorum* Atk. is identical with *Galerina hypnorum* var. *evelata* Sing.; not knowing the type, however, I am unable to interpret Atkinson's species one way or another.

## BOLBITIACEAE

### XXX. NEW SPECIES OF BOLBITIACEAE

#### **Bolbitiaceae** fam. nov.

Epicutis elementis sphaerocystoideis vel piriformibus hymeniformiter dispositis; sporis laetissime ferrugineis vel rarius ferrugineo-fuscis in massa vegeta, levibus, membrana complexa, poro germinativo plerumque praesente; basidiis plerumque breviusculis et crassis, saepissime 2-sporis in formis parallelis normalibus tetrasporis; cheilocystidiis praesentibus; (pleuro-)cystidiis saepe differentiatibus; dermatocystidiis plerumque praesentibus aut in pileo aut in stipite. Fibulis in formis tetrasporis praesentibus. In terra, saepe in pratis, interdum in fimo, rarius in lignis. Cum Coprinaceis comparanda, sed ferrugineospora familia. Genus typicum: *Bolbitius* Fr.

*Observations.* — The old subfamily Bolbitioideae Sing. was certainly a good natural unit; with the disintegration of the family Cortinariaceae, however, this subfamily should, in my opinion, now be considered an independent family. It contains the genera *Pholio-*

<sup>7</sup> The 4-spored form was found in many places in Europe, where it is very common, e.g. Peterhof, Leningrad region, R. Singer, M4-183 (LE). Forma *calypptospora* Kühn. was studied in Karelia (197-M4-326 [LE]), and was in full agreement with Kühner's original description.

tina Fay., Galerella Earle, Tubariopsis Heim, Conocybe Fay., Bolbitius Fr., Cyttarophyllum Heim, and Agrocybe Fay.

**Pholiotina rugosa** (Peck) Sing. comb. nov.

*Pholiota rugosa* Peck, Ann. Rep. N. Y. State Mus., 50: 102. 1897.

This species has been well described macroscopically by Overholts, and all that is needed is a revised microscopical description:

Spores (8.2)  $9.5\text{--}11.2 \times 4.8\text{--}5.8 \mu$ , ellipsoid, seemingly rough because of the granular contents, with moderately thick, compound walls, bright ferruginous fulvous-brown, but not with the very deep color found in *Conocybe*, with a distinct broad germ pore; basidia  $31.5 \times 9.2 \mu$ , 4-spored; cheilocystidia about  $40 \times 10 \mu$ , numerous, ampullaceous; hyphae of the gill trama of the *Pholiotina* type; epicutis of the *Pholiotina* type; all hyphae with clamp connections.

*Observations.* — Our specimens were 7–25 mm. in diameter when fresh; the stipe had a median, more rarely subapical, annulus, which is persistent or slides downward to the somewhat bulbous base; the odor was slightly raphanaceous; in most specimens a broad obtuse umbo was present; the wrinkled surface was not very striking, but was usually clearly apparent; the lamellae were horizontal and adnexed, slightly ventricose in mature specimens. This collection came from the greenhouses of the Waltham Field Station, Massachusetts, E. V. Seeler, February 16, 1944.

The characters of this species are evidently those of a *Pholiotina*, and therefore it is proposed that Peck's species be transferred to that genus.

GOMPHIDIACEAE

XXXI. LATIN DIAGNOSES OF NEW UNITS OF THE NORTH  
AMERICAN GOMPHIDIUS FLORA (PRELIMINARY ACCOUNT)

**Gomphidius leptocystis** Sing. sp. nov.

Pileo demum floccoso-squarruloso, ochraceo vel aurantiaco, ligni-colori vel avellaneo in margine, purpurascente siccando; lamellis cystidiis tenuitunicatis, hyalinis, incrustatis, collabentibus obsitis; sporis pro ratione iis *Gomphidii tomentosi* minoribus; stipite concolori; carne subconcolori-pallidiore; ceterum *Gomphidio tomentoso* et *Gomphidio ochraceo* simillimus est. In silvis coniferis Americae

*Borealis occidentalis*. Typus in Vancouver, Canada, collectus atque in Herbario Michiganensi conservatus est.

*Gomphidius vinicolor* Peck ssp. nov. **californicus** Sing.

A typo cystidiorum abundantia inconsueta constanter differt; mycelio cum *Pinis radiatis* et *Pinis ponderosis* associatus.

*Gomphidius ochraceus* Kauffm. ssp. nov. **muscigenus** Sing.

A typo pileo haud ochraceo-aurantiaco et probabiliter associatione mycorrhizina differt. America Borealis.

Gomphidius, subgenus **Laricogomphus** Sing. subgen. nov.

Carne plus minusve rubente, velo subnullo; subhymenio filamentoso, moderate denso; mediostrato moderate distincto in maturis; dermatocystidiis stipitis fasciculatis plerumque glandulas distinctas formantibus; mycorrhiza cum laricibus.

Gomphidius, subgenus **Myxogomphus** Sing. subgen. nov.

Carne pilei alba vel roseola vel fracta nonnihil rosascente; velo bene evoluto, ex hyphis haud incrustatis subparallelo-subintertextis consistente; subhymenio filamentoso vel filamentoso-subcellulari, moderate denso; mediostrato moderate distincto in maturis; dermatocystidiis stipitis sparsis, haud fasciculatis, glandulis nullis; mycorrhiza variis cum coniferis sed vix cum laricibus observata.

Gomphidius, subgenus *Myxogomphus*, sec. **Macrosporus** Sing. sec. nov.

Sporis maturis 14  $\mu$  majoribus.

Gomphidius, subgenus *Myxogomphus*, sec. **Microsporus** Sing. sec. nov.

Sporis 14  $\mu$  brevioribus.

**Gomphidius septentrionalis** Sing. sp. nov.

Pileo roseolo, viscido, glabro; lamellis ex albo grisellis; sporis 15.7–22.5  $\times$  6–8.5  $\mu$ ; stipite elongato, parte basali laete lutea, velo zonas unam vel duas vel tres glutinosas, angustas ad apicem stipitis

formante vel ex integro membranaceo nec stipitem late cothurnante; carne salmonea, subtus lutea. In silvis piceino-abietinis cum *Boletino glanduloso* in parte septentrionali-orientali Americae Borealis; *Gomphidio roseo* proximus.

### **Gomphidius Smithii** Sing.

Pileo dilute purpurascente-vinaceo vel pallide griseolo-vinaceo; lamellis grisascentibus; sporis  $15-19.5 \times 5.5-6.5 \mu$ ; cystidiis actione formaldehydi in sectionibus KOH imbutis in speciminibus recenter exsiccatis pulchre purpurascentibus; stipite  $50-80 \times 8-12$  mm., albo, hyalino-glutinoso et cothurnato; carne alba, laesa aeris actione rosascente ut minimum in base stipitis, FeSO<sub>4</sub> ope atrata. Sub *Pinis contortis* et *Pseudotsugis taxifoliis*. Oregon Americae Borealis.

### **Var. xanthobasis** Sing.

A typo base lutea differt. Sub *Pinis flexibilibus* in Massachusetts introductis.

### *Gomphidius subroseus* Kauffm. var. **homobasis** Sing.

A typo base stipitis haud vel vix flava differt; cum typo.

### Gomphidius, subgenus **Chroogomphus** Sing. subgen. nov.

Carne plus minusve colorato, velo praesente, ex hyphis parallelis, incrustatis consistente; subhymenio irregulari-intermixto, densissimo; mediostrato haud distincto in adultis; mycorrhiza variis cum coniferis sed vix cum laricibus observata.

HARVARD UNIVERSITY  
CAMBRIDGE, MASSACHUSETTS

SINGER

PLATE I



Photograph by F P Sipe

*Suillus ruber* Singer & Sipe.  $\times$  about  $\frac{1}{3}$



## A POSTGLACIAL FOSSIL FLORULA NEAR FORESTER, MICHIGAN \*

GLADYS F. WEST

THE history of the postglacial predecessors of the present Great Lakes has been preserved by their old beaches and outlets as they passed through their successive stages of growth and development during the time of the recession of the Wisconsin ice sheet from northeastern United States and southeastern Canada. Since this history is intimately associated with the cutting of certain gorges in the Niagara River, the chronology of which has been carefully estimated, it is possible to approximate the ages of most of these lakes and likewise that of any organic remains preserved in their deposits.

Careful study and identification of the plant and animal remains from deposits which can be definitely correlated with any of the postglacial lake stages should eventually make possible a fairly complete picture of the development of vegetation and climate in the Great Lakes region since the retreat of the last ice sheet. So far the deposits of glacial Lake Chicago have received the most attention. Baker (1920) brought together the results obtained by earlier workers and by himself during many years' work and established a florula of 15 species and a fauna of 109 species from the deposits of the various stages of this lake. Recently the Two Creeks forest beds described by Goldthwait (1907) have been studied botanically in two different exposures by Wilson (1932, 1936). He considered these forest beds to have been formed during the Glenwood Stage of glacial Lake Chicago, and he described from both deposits forests composed almost entirely of spruce.

Remains of plants which lived during and after the time of glacial Lake Maumee, a correlative of glacial Lake Chicago, are being described by Hansen (1948), who outlines a gradual develop-

\* Papers from the Department of Botany of the University of Michigan, No. 514.

ment of vegetation from the time of the first appearance of the northern coniferous trees in the region to the time of a mixed deciduous forest.

References to organisms that existed during the time of glacial Lake Algonquin are few and scattered. Hunter (1902) mentioned fossil unios, bones, and pieces of wood from a well boring in a deposit of glacial Lake Algonquin in Simcoe County, Ontario. Tarr (1904) referred to a deposit of logs and pieces of wood near Ithaca, New York, associated with glacial Lake Iroquois, a correlative of glacial Lake Algonquin. Penhallow (1905) identified part of the wood as *Pinus rigida* and *Larix americana*. West (1935) reported wood of *Fraxinus nigra* from a swamp deposit in glacial Lake Tonawanda in New York, a correlative of both Lake Iroquois and Lake Algonquin. Wilson's study (1944) of the sediments in Douglas Lake, Cheboygan County, Michigan, should give valuable chronological information on deposits formed during Algonquin and Nipissing time in that immediate locality.

In the Lake Superior region Wilson (1931, 1935) described plant remains from peat submerged fifty-four feet below the surface of the lake near Sand Island, off the north shore of Wisconsin. This deposit was formed during the time of the Nipissing Great Lakes, while the northern outlet at North Bay, Ontario, was in operation. The tree and shrub species represented were *Taxus canadensis*, *Pinus Strobus*, *P. Banksiana*, *P. resinosa*, *Larix laricina*, *Picea mariana*, *Salix* sp., *Alnus* sp., *Quercus* sp., *Acer spicatum*, *Betula papyrifera*, *B. pumila*, and *Chamaedaphne calyculata*. Taylor (1931, pp. 265-267) has pointed out the importance of this deposit from the standpoint of lake history, since it "appears to supply the first reliable evidence bearing on the depth of submergence of the original Nipissing beach," which was caused by uplift of the land in the north.

Cooper and Foot (1932) described a deposit at Minneapolis, Minnesota, which was formed previous to the inauguration of glacial Lake Agassiz, and reported a florula of thirteen genera, which they described as a bog forest in the lowlands and a "climax forest of white spruce, balsam fir, white pine and birch" in the upland.

The present investigation<sup>1</sup> was undertaken in an effort to ob-

<sup>1</sup> For helpful suggestions and criticisms during the course of this study I am greatly indebted to Professor H. H. Bartlett. I am also under obligation to



tain as much information as possible on the vegetation and climatic conditions which existed during the last or highest stage of glacial Lake Algonquin.

The accumulation of more information of this type should also prove helpful in the interpretation of fossil remains from interglacial periods of the Pleistocene.

#### LOCATION AND DESCRIPTION OF THE FORESTER DEPOSIT

The Forester deposit is located in the southwest quarter of the southeast quarter of Section 28, Forester Township, Sanilac County, T. 13 N., R. 16 E., on the eastern side of the "Thumb" of Michigan, bordering on Lake Huron (Fig. 1). All the plant remains described in this paper were obtained from two exposures, one in the south bank of Big Creek about 365 yards inland from the lake shore, and the other in the north bank of the creek, ranging from 350 to 365 yards inland (Pl. I, Figs. 1-2).

The deposit rests on a mixture of blue-gray plastic clay, sand, and gravel extending down to the water level of the creek. The section in the north bank of Big Creek (Pl. I, Fig. 2) may be described as follows:

<i>Strata</i>	<i>Thickness of strata</i>
4. Surface soil composed of fine lake sand . . . . .	1 ft. 8 in.
3. Grayish-tan lake clay . . . . .	2½-3 ft.
2. Grayish-brown marly and peaty laminated clay . . . . .	3-3½ ft.
1. Leaf bed composed of layers of leaves interbedded with layers of fine buff-colored silt . . . . .	3-3½ ft.

At the time the collections were made some of the fossil leaves in Stratum 1 were weathered out of their matrix and were hanging in ragged masses from the side of the bank (Pl. II, Fig. 1). From their midst the end of a partially crushed sycamore trunk protruded (Pl. I, Fig. 2).

the late Dr. Frank Leverett for personally visiting the deposit and for much information concerning the geological history and development of it. My appreciation is expressed to Dr. W. C. Steere for the identification of the thirteen species of fossil mosses. Thanks are due to Mr. L. A. Harris for photographs and information concerning the location of the deposit; to Dr. E. A. Bessey for some of the seeds used for identification of the fossil specimens; and to the Michigan State Seed Laboratory for the privilege of using specimens in their seed herbarium. Grateful acknowledgment is made to Dr. Ethel B. Hansen for much assistance in the collection of the fossil material during the summers of 1931 and 1932.

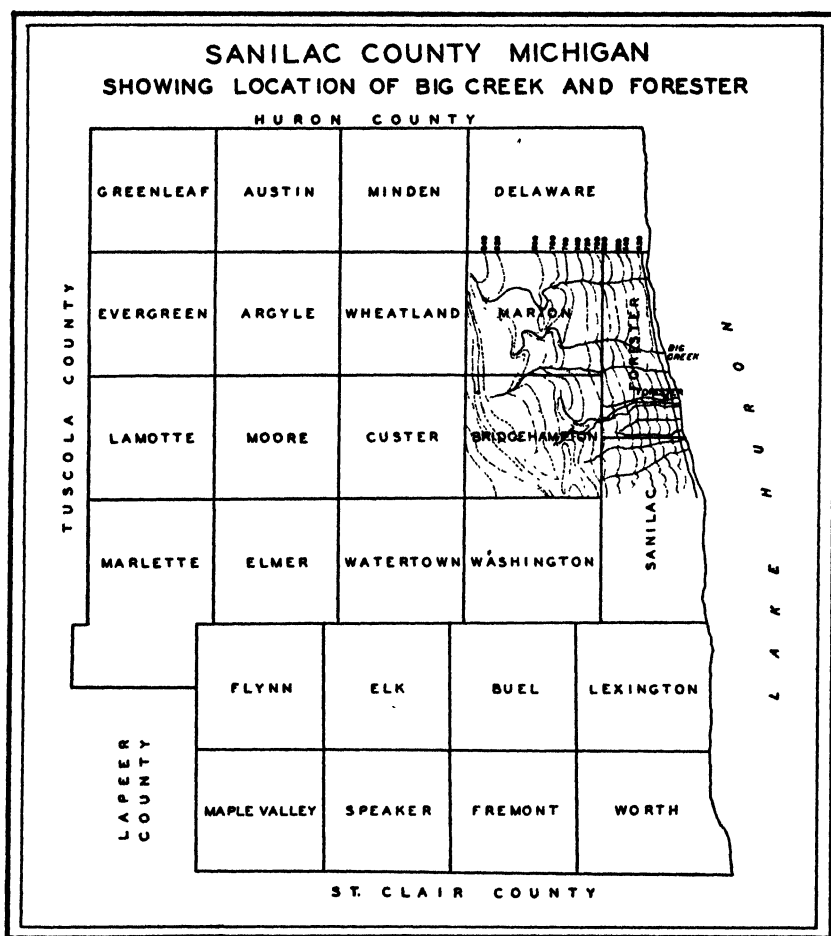


FIG. 1

(Based upon a map by C. H. Gordon, *Geological Report on Sanilac County, Michigan*, Geol. Surv. Mich., Vol. VII, Part 3)

#### GEOLOGICAL HISTORY AND DEVELOPMENT OF THE DEPOSIT

The history and development of the Forester deposit is so intimately associated with the history of certain of the Great Lakes that to give the history of one is to give the history of the other. It begins about thirty thousand years ago, when the Wisconsin

ice sheet began to retreat from northeastern United States. The early period of the recession of the ice front was characterized by a slow retreat to the southern watershed of the Great Lakes basins, where it assumed a lobate outline corresponding roughly with the lake basins. The melt waters were gathered into small lakes along the margins of the ice lobes, and were dammed up between the ice barrier and the higher land of the watershed. These small lakes, formed at different times and fed by the melting ice, developed into vast bodies of water of much greater magnitude than our present Great Lakes system (Leverett and Taylor, 1915, pp. 318-321).

The actual development of the Forester deposit began at the time when the margin of the continental ice sheet had retreated sufficiently for the glacial waters in the basins of Lake Superior, Lake Michigan, Lake Huron, and Georgian Bay to be free to unite into one vast body of water at one level, known as the Second or Kirkfield stage of Lake Algonquin (Leverett and Taylor, 1915, pp. 410-411). This lake drained through an outlet near Kirkfield, Ontario, eastward through the Trent Valley into glacial Lake Iroquois, which lay in the Lake Ontario basin (Leverett and Taylor, 1915, p. 412; Leverett, 1917, p. 137). By this time the channel of Big Creek at Forester was already in existence and flowing into Lake Algonquin (the late Dr. Leverett, personal communication). Perhaps more than half of postglacial time had already elapsed.

After the ice had almost entirely disappeared from the northern part of the lake basins a differential uplift of the land surface began in the Trent Valley, which resulted in a gradual rise of the Kirkfield outlet (Leverett and Taylor, 1915, pp. 329, 410). While the region around the northern outlet was being gradually tilted upward, the level of the land around the southern part of the lake remained stationary. The water was thus gradually shifted to the south and began to back up on higher land and submerged the Kirkfield beaches. With the gradual rise of water level in the south it became correspondingly lower in the north, until eventually the Kirkfield beaches were abandoned. South of a line running "from Kirkfield west-northwest, passing about 20 miles south of Sault Ste. Marie," the waters rose to a higher level on the land, and the beaches of the Kirkfield stage were submerged and destroyed (Leverett and Taylor, 1915, p. 413). North of this line they were abandoned,

and new beaches formed at a lower level. The two southern outlets at Chicago and Port Huron gradually came to receive more and more of the overflow. But for a long time all three outlets were in use during a transitional three-outlet stage. Eventually the northern outlet was totally abandoned, and the two southern outlets discharged the entire overflow. However, the Port Huron outlet, which was on a clay foundation, was rapidly cut down to a lower level than the Chicago outlet, which lay over a rock sill. The entire discharge then passed through Port Huron (Leverett and Taylor, 1915, pp. 410, 414; Leverett, 1917, p. 138), southward into Lake Erie and eventually into the Niagara River. This represents the last or highest stage of Lake Algonquin.

As a result of the uplift in the north, in the vicinity of Forester the waters rose to 607 feet above sea level, as is shown by the beach of the highest stage of Lake Algonquin. Accordingly, the waters had also backed up into the mouth and valley of Big Creek to a point 607 feet above sea level and formed an estuary.

The deposit at Forester is represented in two sections exposed by the present channel of Big Creek as it cut through the old silted-up estuary. The bottom of the exposure, composed of gravel, sand, and blue-gray plastic clay, probably represents the bed of the old creek channel, which was gradually submerged by the rising Algonquin waters.

The leaves in Stratum 1 (Pl. I, Fig. 2) appear to have been deposited during the early part of the uplift, while the estuary was being formed and the water was still shallow. They were probably blown into the creek and carried downstream, finally coming to rest at the mouth of the channel, where it emptied in the shallow water of the estuary. The presence of certain fossil remains (which will be described later) in Strata 2 and 3 above the leaf layer indicates a rise of several feet in water level of the estuary caused by the continued uplift in the north.

A further retreat of the ice in southern Canada uncovered a lower outlet at North Bay, Ontario, in the Mattawa Valley, which eventually came to receive all the overflow and resulted in the inauguration of the Nipissing Great Lakes (Leverett and Taylor, 1915, p. 330; Leverett, 1917, p. 138). The Nipissing Great Lakes endured until a differential uplift in the Mattawa Valley raised the level of the North Bay outlet sufficiently for the discharge to

be again shifted to the southern outlet at Port Huron, which resulted in the post-Nipissing or modern stage of the upper three Great Lakes.

At the close of Lake Algonquin the ice front probably stood ten to twenty-five miles north of Lake Superior, and north of the line of the Canadian Pacific Railway, which passes through Franz and Sudbury, Ontario, southeastward to Mattawa, Ontario, and thence eastward through southern Quebec (Antevs, 1931, pp. 13, 15), a distance of approximately 270 miles from Forester. At the inauguration of the second or Kirkfield stage the ice front, which stood near Kirkfield, Ontario, was approximately 210 miles distant from Forester. From that time until the close of the last or highest stage the ice front had receded approximately 60 miles. It can be reasonably estimated, therefore, that at the time of the formation of the estuary in Big Creek during the last stage of Lake Algonquin the ice front stood approximately 240 to 250 miles away from a forest growing in the valley of Big Creek, abundant remains of which have been buried and preserved in the silts of the estuary.

#### AGE OF THE DEPOSIT

The age of such a deposit is always a matter of considerable interest. As shown by measurements of the rate and the amount of recession of the Horseshoe Falls, the age of the Upper Great Gorge in the Niagara River may be about 4,000 years (Kindle and Taylor, 1914, p. 170; Taylor, 1929, p. 262; Dr. Leverett, personal communication). Since the Upper Great Gorge was formed after the drainage of the Nipissing Great Lakes was diverted from the Mattawa-Ottawa valleys back to the southern outlet at Port Huron, so that the discharge of the upper three Great Lakes and Lake Erie passed into the Niagara River (Kindle and Taylor, 1914, p. 154, fig. 14), the amount of time required to cut the Upper Great Gorge also represents the length of time during which the upper three Great Lakes discharged through the southern outlet. The northern outlet of the Nipissing Great Lakes has been estimated to have been in operation for from 2,000 to 2,500 years (Taylor, 1929, p. 260). The amount of erosion accomplished by the last or highest stage of glacial Lake Algonquin while it discharged to the south is so slight that it would probably not have taken over 4,000 years; and the length of time might be estimated to have been even less,

except for the fact that for a while the southern discharge was divided between two outlets, viz., Chicago and Port Huron (Dr. Leverett, personal communication). The deposit, the formation of which began in the early part of the last or highest stage of Lake Algonquin, may then be about 10,500 years old and is, therefore, of considerable antiquity.

## CLASSIFICATION AND DESCRIPTION OF PLANT REMAINS

### THALLOPHYTA

#### CHARACEAE

##### *Chara* sp.

Cooper and Foot, 1932, pp. 69, 70; Baker, 1920, pp. 26, 94, 101.

Nutlike oögonia incrusted with calcium carbonate were present in large numbers in Strata 2 and 3. Their absence from Stratum 1 (the leaf bed) has been interpreted to mean that the deposition at that level was in very shallow water, and probably took place during the time when the water level of Lake Algonquin was slowly rising in the south and had begun to creep back into the channel of Big Creek.

### BRYOPHYTA

MacBride, 1896, pp. 63-66; Cheney, 1930, pp. 66-68; 1931, pp. 93, 94; Williams, 1930, p. 33; Cooper and Foot, 1932, pp. 63-72; Wilson, 1932, pp. 31-46; 1936, p. 320; Berry, 1933, 7; Voss, p. 1933, p. 813; Steere, 1941, pp. 83-89; Hansen, 1948, p. 53.

Remains of the vegetative structure of the following thirteen species of mosses, which were found in the leaf bed, were identified by Dr. W. C. Steere:

#### Aulacomniaceae

*Aulacomnium heterostichum* (Hedw.) Bry. Eur.

#### Leucodontaceae

*Leucodon sciurioides* (L.) Schwaegr. (Pl. III, Fig. 1)

#### Thuidiaceae

*Anomodon attenuatus* (Schreb.) Hübner. (Pl. III, Fig. 2)

*Anomodon rostratus* (Hedw.) Schreb.

*Thuidium delicatulum* (L.) Mitt. (Pl. II, Figs. 2-3)

#### Amblystegiaceae

*Amblystegium varium* (Hedw.) Lindb.

*Campylium radicale* (P. B.) Grout

*Drepanocladus aduncus* (Hedw.) Warnst.

*Leptodictyum riparium* (Hedw.) Warnst.

Brachytheciaceae

*Bryhnia novae-angliae* (Sull. and Lesq.) Grout

*Eurhynchium strigosum* (Hedw.) J. and S. (Pl. III, Figs. 3-4)

Plagiotheciaceae

*Plagiothecium denticulatum* (L.) Bry. Eur.

Hypnaceae

*Hypnum imponens* Hedw.

Of this group, *Anomodon attenuatus* (Schreb.) Hübén. was represented the most abundantly, and *Leucodon sciuroides* (L.) Schwaegr. ranked second in frequency of occurrence.

All these species are common in northeastern United States, and all are found in the present flora of Michigan. For the most part they represent species which can be found growing in a beech-maple forest on moist shaded banks of streams, on stones, and on tree trunks, with the exception of *Drepanocladus aduncus* (Hedw.) Warnst., which is aquatic, and *Leptodictyum riparium* (Hedw.) Warnst., which is subaquatic.

PTERIDOPHYTA

POLYPODIACEAE

*Onoclea sensibilis* L. (Sensitive fern)

(Pl. IV, Fig. 1)

A small portion of a fertile frond, the pinnules of which still retain on their lower surfaces a few characteristic sporangia with spores, represents the only remains of this species. The sensitive fern is found abundantly in wet places throughout Michigan. The genus has not hitherto been reported in the Pleistocene of this country.

SPERMATOPHYTA

PINACEAE

*Pinus Strobus* L. (White pine)

(Pl. IV, Fig. 7)

Safely, 1867, p. 116; Penhallow, 1896, p. 67; 1898, p. 526; Cooper and Foot, 1932, pp. 66, 69; Wilson, 1935, pp. 533-535; Hansen, 1948, p. 54.

The lower half of a single mature cone from Stratum 2 represents the only remains of this species.

White pine is found in Michigan throughout the Upper Peninsula

and as far south in the Lower Peninsula as Allegan, Eaton, and St. Clair counties, approximately fifty miles farther south than its occurrence as a fossil near Forester.

*Pinus sp.*

Pollen representing at least two species of pine was noted.

*Larix laricina* (DuRoi) Koch. (Tamarack)

Safely, 1867, p. 116; Keyes, 1893, p. 357; Dawson and Penhallow, 1890, p. 326; Penhallow, 1896, pp. 60, 61, 67, 69; 1898, pp. 526, 527; 1905, pp. 69-70; MacBride, 1896, pp. 65, 66; Calvin, 1898, p. 240; Coleman, 1899, pp. 35, 36; Tarr, 1904, pp. 78, 79; Baker, 1920, pp. 42, 71; Cooper and Foot, 1932, p. 69; Voss, 1933, p. 814; Wilson, 1935, pp. 533-535; Hansen, 1948, p. 54.

A single fragmentary twig bearing one short lateral branchlet was found in the lower part of Stratum 2. The specimen has been arbitrarily assigned to *Larix laricina*, the only species native to northeastern United States, since there was no distinctive character present which would definitely mark it as this particular species and since the facies of the fossil florula resembles so closely that of the present in many parts of the Lower Peninsula of Michigan.

Tamarack is common in swampy areas throughout Michigan.

*Picea sp.* (Spruce)

Spruce is represented by pollen only. Although it has not been possible definitely to identify the species to which it belongs, it seems probable that it may represent *Picea mariana* (Mill.) BSP., from a swampy area near by.

*Tsuga canadensis* (L.) Carr. (Hemlock)

(Pl. IV, Figs. 2-4)

Hemlock was one of the most commonly represented species. Small twigs, needles, cones, and seeds were abundant in Strata 1 and 2. *Tsuga* pollen, undoubtedly referable to this species, was also found.

Hemlock occurs throughout Michigan today except in the southeastern part of the Lower Peninsula, where it extends as far south as Port Huron (Quick, 1923) along the eastern side.



*Thuja occidentalis* L. (Arbor vitae)

(Pl. IV, Figs. 5-6)

Dawson and Penhallow, 1890, pp. 324, 325; Wegeman, 1909, pp. 26, 27; Baker, 1920, pp. 42, 71, 101.

This species is sparingly represented in Strata 1 and 2 by small twigs with leaves, two mature open cones, and a few seeds.

Arbor vitae is common in low situations throughout the northern two thirds of Michigan; it extends as far south as Montcalm and Sanilac counties. According to Dodge (1912, p. 37), it is plentiful near the Lake Huron shore as far south as St. Clair County.

## TYPHACEAE

*Typha* sp. (Cattail flag)

Penhallow, 1896, p. 64.

The genus *Typha* is represented by pollen only, and the species was not determined.

## SPARGANIACEAE

*Sparganium* sp. (Bur reed)

(Pl. IV, Fig. 8)

Berry, 1914, p. 160; 1924, p. 16.

Achenes representing at least two different species were found abundantly in Stratum 2.

## NAJADACEAE

*Potamogeton* sp. (Pondweed)

(Pl. IV, Figs. 9, 11)

Dawson and Penhallow, 1890, pp. 327, 331; Knowlton, 1896, p. 371; Penhallow, 1896, pp. 65, 66; 1898, p. 528; Coleman, 1915, p. 247; Baker, 1920, pp. 27, 39, 91; Hollick, 1931, pp. 37-39, pl. 2; Cooper and Foot, 1932, p. 69.

This genus is represented by a great many well-preserved achenes, representing at least three different species, found in Strata 2 and 3. Their presence in these two strata, along with remains of *Chara* and *Myriophyllum*, would seem to indicate a water depth of four or five feet or even more during the time of deposition. Their absence from Stratum 1 (the leaf bed) has, therefore, been interpreted to mean shallower water at that level.

## ALISMACEAE

*Sagittaria latifolia* Willd. (Arrowhead)

(Pl. V, Fig. 1)

Achenes of *Sagittaria latifolia* were very common in Strata 2 and 3. In the present flora it is abundant throughout Michigan in wet places. This is the first reported occurrence of the genus in the Pleistocene of this country.

*Alisma Plantago-aquatica* L. (Water plantain)

This species is represented by a small number of achenes in Stratum 2. At the present time it is common and abundant in shallow water and ditches throughout Michigan. The presence of water plantain has not previously been reported in the Pleistocene of this country.

## CYPERACEAE

*Dulichium arundinaceum* (L.) Britton

(Pl. V, Fig. 2)

Berry, 1924, p. 18, pl. I, figs. 17-18.

Two achenes represent the only remains of *Dulichium arundinaceum*. It is found abundantly in the present flora of Michigan in wet swampy places on the borders of streams, ponds, and small lakes.

*Eleocharis olivacea* Torr. (?) (Spike rush)

Small black achenes 1.25 mm. long, 0.75 mm. wide, obovate, with fragmentary tubercle, and bristles absent, resembling very closely *Eleocharis olivacea*, were present in considerable numbers in Strata 2 and 3.

This species has been found in both the Upper and the Lower peninsulas of Michigan, but it appears to be rather rare in the state.

No previous discovery of the gross remains of the genus *Eleocharis* has been recorded in the Pleistocene of this country.

*Carex lupulina* Muhl. (Sedge)

(Pl. V, Fig. 3)

Well-preserved achenes were found in Strata 2 and 3, which corresponded so closely with those of *Carex lupulina* that the de-

termination has been made without hesitation. In the present flora it is of common occurrence in swamps and wet places throughout Michigan.

Although *Carex* has been reported from both early and late Pleistocene deposits in this country, there is no previous record of this species.

*Carex retrorsa* Schwein.

(Pl. V, Fig. 4)

Hansen, 1948, p. 56.

Triangular-fusiform achenes resembling so closely the achenes of *Carex retrorsa* that it seems unquestionable that they belong to this species. It is one of the commonest sedges in Michigan.

*Carex Schweinitzii* Dewey (?)

(Pl. V, Fig. 5)

Achenes obovoid; equally 3-angled; 1.75 mm. long; styles fragmentary; perigynium incomplete, 3.5 mm. long; 1.5 mm. wide; few-nerved and very delicate. These achenes resemble more closely the achenes of *Carex Schweinitzii* than those of any other American species in the genus.

The species is not abundant in Michigan, and has been reported from only three counties in the Lower Peninsula, viz., Crawford (Beal, 1904, p. 57), Cheboygan (Gates and Ehlers, 1924, p. 212), and Ottawa (herbarium specimen in the University of Michigan Herbarium).

No previous occurrence of the species has been reported from the Pleistocene of this country.

SALICACEAE

*Salix* sp. (Willow)

The presence of *Salix* is represented by pollen alone. More than one species appears to be present. In all probability they grew in close proximity to the place of deposition.

There are a number of references to the occurrence of *Salix* during postglacial time, as well as earlier in the Pleistocene.

## JUGLANDACEAE

*Carya* sp. (Hickory)

The only remains of this genus thus far found are deposits of pollen. The nature of the fossil florula is such as would indicate that hickory grew in a dry upland area some distance away from the place of deposition.

Several different species of hickory have been reported from the Pleistocene of this country.

## BETULACEAE

Pollen representing certain members of the Betulaceae was found to be relatively abundant.

*Carpinus caroliniana* Walt. (Blue beech)

(Pl. VI, Figs. 6-9)

Berry, 1907a, p. 692; 1907b, pp. 340-341; 1910, p. 395; 1926, p. 108.

Remains of the blue beech were common in Strata 1 and 2 in the form of practically skeletonized leaves, bractlets, and a great many flattened nuts.

In Michigan blue beech occurs locally along streams and in wet places and is found most frequently in the southern part of the state.

*Betula* sp. (Birch)

Penhallow, 1896, p. 66.

A few seeds resembling very closely both *Betula lutea* Michx. f. and *Betula lenta* L. were found in Strata 1 and 2. There seems to be a sufficient amount of variation in the seeds of these two modern species to make an exact specific identification questionable. The composition of the fossil florula is such as to indicate the possible presence of both. Both species, although occurring throughout the state, are most common in the northern part.

*Betula alba* L. var. *papyrifera* (Marsh.) Spach.

Safely, 1867, p. 116; Emerson, 1898a, p. 740; 1898b, p. 7; 1917, p. 148; Cooper and Foot, 1932, p. 69; Wilson, 1935, pp. 533-535.

This species is represented by a single seed, small cylinders of bark, and a few pieces of wood. The seed is unquestionably that

of *Betula alba* L. var. *papyrifera*, since the shape, size, and cell structure of the wings correspond identically with those features in this particular species and variety.

Although the wood structure was found to resemble very closely that of the paper birch, the identification is given with some hesitation, since certain of the diagnostic characters have been obscured as a result of decomposition and crushing.

Paper birch in Michigan occurs from Lansing northward, although Dodge (1912, p. 31) found it quite common a little farther south along the Lake Huron shore in St. Clair County.

#### FAGACEAE

##### *Fagus grandifolia* Ehrhardt (Beech)

(Pl. VII, Figs. 1-8; Pl. VIII, Figs. 1-4)

Orton, 1873, pp. 427-428; Knowlton, 1896, p. 371; Mercer, 1899, pp. 279, 281; Emerson, 1898a, p. 740; 1898b, p. 7; 1917, p. 148; Hollick, 1906, p. 226; Berry, 1906, pp. 88-89; 1907a, pp. 692-693, pl. 2, fig. 7; 1907b, p. 341; 1909, p. 435; 1910, pp. 393-394; 1914, p. 162; 1915, pp. 206-207; 1926, p. 108, pl. 48, figs. 3-13; 1927, p. 25; 1933, p. 11; Baker, 1920, p. 312.

Beech was the most common member of the fossil florula, and was represented by a large number of well-preserved leaves, bud scales, flattened burs and nuts, a small twig bearing a terminal bud, a single specimen of wood, and pollen. Leaves of this species were more abundant than those of any other species and, along with leaves of *Acer saccharum*, formed 85 per cent or more of the leaf bed. The pollen can be referred to this species with little doubt.

The wood structure was well preserved and corresponds identically with that of the modern beech (Brown and Panshin, 1940, pp. 446-448; Record, 1934, pp. 131, 132). Since published descriptions of Pleistocene wood are few, it has been thought advisable to describe the structure of some of the wood from this deposit.

*Transverse section.* — Annual rings 1.0 to 1.25 mm. wide. Diffuse-porous. Vessels angular to round or oval. Fibers still retain their shape, but in many specimens the secondary wall has disorganized, so that only the thin primary wall remains.

*Radial section.* — Vessel segments rather long; without spirals; end walls oblique, with perforations scalariform to simple; tyloses abundant. Rays heterogeneous.

*Tangential section.* — Tyloses present a thin platelike appearance. Rays short-uniseriate to large compound structures.

Beech occurs throughout Michigan, but is more abundant in the Lower Peninsula, and is a prominent member of the climax forest in the locality where the fossil material was collected.

### *Quercus* sp. (Oak)

The only remains of this genus thus far found in the deposit consist of pollen. The complete absence of any other remains of oak indicates that it probably was not a component part of the vegetation along the creek, but grew in a higher, drier upland area some distance away from the place of deposition.

There are many references to the occurrence of *Quercus* during postglacial time as well as throughout the Pleistocene.

### URTICACEAE

#### *Ulmus americana* L. (American elm)

(Pl. IX, Figs. 1-4)

Penhallow, 1896, p. 68; 1898, p. 528; 1907, pp. 449, 450; Berry, 1915, p. 207.

This species is represented by a large number of leaves and fifteen identified specimens of wood from Strata 1 and 2. Although no complete specimens of leaves were obtained, it was possible to distinguish them from *Ulmus fulva* Michx. by means of the venation.

Excluding the effects of disintegration, the wood structure corresponds exactly with that of the modern species (Record, 1934, pp. 120-121, pl. 3, fig. 2; Brown and Panshin, 1940, pp. 462-464).

*Transverse section.* — Annual rings variable in width, 0.25 to 1.5 mm., and usually visible to the unaided eye. Ring porous. Vessels of spring wood large, oval, elliptical to slitlike, and, with few exceptions, arranged in a single tangential row. Summer wood vessels irregularly angular; arranged for the most part in wavy tangential bands. Tyloses present in both early and late vessels. Wood parenchyma vasicentric, scarcely distinguishable in poorly preserved specimens; in better-preserved specimens distinguishable by brownish contents; shape usually distorted. Fibers arranged in bands alternating with the bands of summer vessels. The fibers seem to have undergone the greatest amount of decomposition. In only a few specimens were the outlines of individual fiber cells dis-

tinguishable. In some the primary wall was distorted, and the secondary wall was present in the form of a small irregular mass lying to one side of the cell; in others the secondary wall had entirely disappeared. Rays 1 to 6 cells wide.

*Radial section.* — Vessel segments short; tertiary spiral thickenings still present in some of the summer vessels; end walls horizontal to oblique; perforations simple. Tyloses abundant. Wood parenchyma arranged in vertical strands of 2 to 6 cells. Rays homogeneous.

*Tangential section.* — Rays range from short, uniseriate to multi-seriate structures 2 to 6 cells wide, and 9 to 40 or more cells high. Ray cells distorted because of radial crushing.

In the present flora white elm is common throughout Michigan.

*Ulmus sp.*

Pollen representing one or more species of elm was found to be relatively abundant. Both *Ulmus americana* and *U. fulva* were probably represented.

*Laportea canadensis* (L.) Gaud. (Wood nettle)

(Pl. X, Figs. 11-13)

Characteristic achenes of wood nettle were common in the leaf bed. This species occurs throughout Michigan, but appears to be more common in the southern part of the state (Quick, 1923, p. 226).

It has not previously been reported from the Pleistocene of North America.

*Boehmeria cylindrica* (L.) Sw. (False nettle)

A single achene found in the leaf bed represents the only remains of *Boehmeria cylindrica*. In the present flora of Michigan it is found only in the Lower Peninsula.

There has not been a previous report of the occurrence of the genus in the Pleistocene of this country.

POLYGONACEAE

*Polygonum acre* HBK. (Water smartweed)

The characteristic black shining achenes of *Polygonum acre* were found occasionally in Stratum 2. In Michigan, water smart-

weed inhabits swamps and wet places throughout the state, but it occurs more abundantly in the Lower Peninsula.

Although the genus has been reported previously from the Pleistocene of the United States, this represents the first occurrence of *Polygonum acre*.

#### RANUNCULACEAE

##### *Ranunculus septentrionalis* Poir. (Swamp buttercup)

Emerson, 1898b, p. 7; 1917, p. 148; Berry, 1924, pp. 20, 24; 1933, pp. 15-17.

Flat, margined achenes with fragmentary styles were frequent in Strata 1 and 2. Swamp buttercup is common throughout Michigan.

The genus has been reported previously from the Pleistocene of this country, but this is the first record of *Ranunculus septentrionalis*.

##### *Ranunculus recurvatus* Poir.

(Pl. V, Fig. 6)

A single achene 2.75 mm. long by 2 mm. wide, flat, with a somewhat fragmentary style, was found in Stratum 1. Although the fossil specimen resembles very closely achenes of *Ranunculus recurvatus* Poir., the final identification was made on the basis of the cell structure, which seems to resemble that of this species more closely than that of any other. In the present flora the species is common throughout Michigan.

It has not been previously reported from the Pleistocene of this country.

##### *Anemone* sp.

(Pl. V, Fig. 7)

A single achene, flat, smooth, with style somewhat fragmentary, was found in Stratum 2. The shape, size, and cell structure of this specimen resemble very closely these features in both *Anemone virginiana* Walt. and *A. cylindrica* Gray. The nature of the fossil flora is such as to indicate that the habitat conditions around the place of deposition were probably more suitable for *Anemone virginiana* than for *A. cylindrica*. Both species appear to be more frequent in the Lower Peninsula of Michigan than in the Upper Peninsula.

This is the first reported occurrence of the genus in the Pleistocene of this country.



## PLATANACEAE

*Platanus occidentalis* L. (Sycamore)

(Pl. XI, Figs. 1-3; Pl. XII, Figs. 1, 3)

Knowlton, 1896, p. 371; Penhallow, 1896, p. 68; 1898, p. 526; 1907, p. 448; Mercer, 1899, p. 277; Emerson, 1898a, p. 739; 1898b, p. 7; 1917, p. 148; Berry, 1907a, pp. 695, 696; 1907b, p. 344; 1910, p. 397; 1914, p. 161; 1915, pp. 207-208; 1926, p. 112; 1933, pp. 11-12.

This species is represented by a great many leaves, a few seeds, a large log, and several smaller pieces of wood. Because of the large size of the leaves it proved to be impossible to secure unbroken specimens. Petioles with the characteristic large hollow base and detached from the leaf blades were frequent. The log (Pl. I, Fig. 2) measured 28 inches in diameter, and 109 annual rings were counted.

Although the original appearance of the wood was changed considerably because of crushing and decomposition, most of the diagnostic characters were present (Record, 1934, pp. 130-131; Brown and Panshin, 1940, pp. 482-483).

*Transverse section.* — Annual rings 2 to 4 mm. wide. Diffuse-porous. Vessels narrowly elliptical to slitlike, a shape caused by radial crushing of the log. Wood parenchyma diffuse; shape of individual cells distorted. Ray cells have abundant reddish-brown contents.

*Radial section.* — Vessel segments short; without spirals; end walls usually oblique; perforations simple or scalariform; horizontal full-bordered pits; tyloses abundant. Rays homogeneous.

*Tangential section.* — Vessels radially crushed. Rays broad; 8 to 14 cells wide and 6 to 7 times as high. Ray cells distorted because of radial crushing. Wood parenchyma and wood fibers practically indistinguishable; pitting obscure.

Along the eastern side of Michigan the northern limit of sycamore is the Saginaw Bay region (Dodge, 1911, p. 96; 1921a, p. 195). In the central part of the state it is reported as far north as Roscommon County (Illick, 1927, p. 61).

## ROSACEAE

*Crataegus* sp. (Hawthorn)

(Pl. XII, Fig. 2)

A single incomplete specimen of a leaf, 2.25 inches long by 1.25 inches wide; serrate-dentate, and appears to have been entire

and cuneate at the base, and acute or rounded at the apex. There is some similarity to leaves of *Crataegus Crus-galli* L.

The genus has been reported a number of times from the Pleistocene of this country.

*Rubus idaeus* L. (?)

(Pl. X, Fig. 3)

Seeds irregularly bean-shaped; 2 to 2.5 mm. long; 1 mm. wide; somewhat flattened; coarsely and irregularly reticulate-ridged; raphe conspicuous; seeds sometimes hollow and somewhat shriveled. The seeds resemble very closely those of *Rubus idaeus* L., although they are somewhat smaller than those of either the species or the variety *aculeatissimus* [C. A. Mey.] Regel & Tiling, which is common in Michigan. It is quite possible, however, that *Rubus idaeus* L. or some form of it is represented. Both *R. idaeus* and the variety *aculeatissimus* are common throughout Michigan.

Although this genus has been reported previously from the Pleistocene of this country, no specific identifications have been made.

*Rubus allegheniensis* Porter (?)

(Pl. X, Fig. 4)

Hansen, 1948, p. 58.

This identification was made on the basis of two seeds. Seeds broadly ovoid, 1.75 to 2 mm. long; 1.25 to 1.5 mm. wide; somewhat compressed; coarsely and irregularly reticulate-ridged, with a conspicuous margin extending around them from hilum to end of the raphe; raphe conspicuous. These specimens unquestionably belong in the blackberry group and resemble *Rubus allegheniensis* Porter in every respect except size, since they are slightly smaller. This species also is common throughout Michigan.

*Agrimonia* sp. (Agrimony)

(Pl. X, Figs. 8-9)

Three fruits, found in Stratum 2, were 3.75 mm. long by 3.25 mm. wide; flattened; bristles absent from the marginal rim; conspicuous longitudinal ridges present which are characteristic of the fruits of *Agrimonia*. Sufficient diagnostic characters were not present to make possible a specific identification.

The genus has not hitherto been reported from the Pleistocene of North America.

## RUTACEAE

*Zanthoxylum americanum* Mill. (Prickly ash)

(Pl. X, Figs. 7, 10)

Hansen, 1948, p. 58.

A few seeds and a great many characteristic thorns were found in Strata 1 and 2. Prickly ash occurs in the Lower Peninsula of Michigan and is characteristic of the shrub zone in the beech-maple climax association.

## ACERACEAE

*Acer saccharum* Marsh. (Sugar maple)

(Pl. XIII, Figs. 1-3; Pl. XIV)

Dawson and Penhallow, 1890, pp. 329-330; Emerson, 1898a, p. 739; 1898b, p. 7; 1917, p. 148.

The sugar maple, one of the commonest members of the fossil flora, was represented by leaves, seeds, and wood. The leaves of this species were the second most abundant and, along with those of beech, made up 85 per cent or more of the leaf bed (Stratum 1).

The seeds were flattened, with the wings either fragmentary or entirely absent. The wood was poorly preserved, and all the necessary diagnostic characters (Record, 1934, pp. 128-129; Brown and Panshin, 1940, pp. 494-496) were recognized only after sectioning several pieces.

*Transverse section.* — Annual rings 1.0 to 1.4 mm. wide. Diffuse-porous. Vessels oval, narrowly elliptical to slitlike; single, or in radial rows of 2 to 6; vessel walls partially to entirely disintegrated. Brown gummy substance frequent in vessels, or in the spaces left after decomposition of the vessels. Fibers mostly collapsed.

*Radial section.* — Vessel segments short; spirals distinguishable in some vessels; end walls oblique; perforations simple. Gummy deposits in the form of horizontal plates or round masses present in the vessels, as in modern wood, but more abundant. In the disintegrated vessels the gummy deposits often formed casts showing the impression of the spirals. Rays homogeneous.

*Tangential section.* — Rays varying from short-uniseriate to large

structures 7 or 8 cells wide and 80 or more cells high. Pitting on fibers obscure.

In the present flora sugar maple is found throughout Michigan.

*Acer saccharum* var. *Rugelii* Rehd. (?)

(Pl. XV, Figs. 1-2)

A large leaf differing from those of *Acer saccharum* Marsh. in that it is 3-lobed and 3-veined, with an entire to slightly undulated margin, has been found to resemble very closely *Acer saccharum* var. *Rugelii* Rehd., as described by Sargent (1926). The long slender lateral lobe of the fossil specimen agrees better with the description of variety *Rugelii* than with that of variety *nigrum* which, on the whole, has much broader and shorter lobes.

Another leaf (Pl. XV, Fig. 2), also representing some form of these species, although fragmentary, was found to resemble closely the base of a small leaf of variety *Rugelii*. However, in view of the fact that a great deal of natural variation is found in the leaves of *A. saccharum*, all that can be said with certainty is that these leaves represent variations of the species named above.

Variety *Rugelii*, according to Sargent (1926), may extend as far north as the Southern Peninsula of Michigan and southern Ontario. Although it does not appear in any published reports on the flora of Michigan, herbarium specimens of it that were collected at Port Huron and Isle Royale are in the herbarium at the University of Michigan.

*Acer* sp.

Pollen representing members of this genus was relatively abundant.

VITACEAE

*Vitis vulpina* L. (River-bank grape)

(Pl. X, Fig. 5)

Hansen, 1948, p. 58.

A single seed from Stratum 1 has been referred to this species. There are many reports of the occurrence of grape in both interglacial and postglacial periods, but only a few specific identifications have been certainly made.

## TILIACEAE

*Tilia americana* L. (Basswood)

(Pl. VI, Figs. 1-5)

Penhallow, 1898, p. 528; 1907, p. 449.

Basswood is represented in the leaf bed by a number of leaf fragments and a great many bracts and fruits. The leaf specimens were referred to *Tilia americana* L. on the basis of the coarse, deep serration of the margin, the long incurved points of the teeth, and the long slender, abruptly acute apex. The bracts resembled those of this species more closely in general shape and size than those of any other species of the genus native to this country.

*Tilia americana* is found throughout Michigan.

## HALORAGIDACEAE

*Myriophyllum* sp. (Water milfoil)

(Pl. IV, Fig. 10)

A number of small pectinate-pinnatifid floral leaves, 3 to 5.5 mm. long, referable to some species of *Myriophyllum*, were found in Stratum 3. There was no indication of their presence in the two lower strata.

The genus has not previously been reported from the Pleistocene.

## CORNACEAE

*Cornus stolonifera* Michx. (Red-osier dogwood)

(Pl. V, Figs. 8-9)

A small number of seeds characteristic of this species were found in the leaf bed; also a few small, undeveloped fruits of some species of dogwood. The red-osier dogwood is common throughout Michigan.

The genus has been reported a number of times in the Pleistocene of this country, but this is the first record of *Cornus stolonifera* Michx.

*Nyssa sylvatica* Marsh. (Black gum)

(Pl. VII, Fig. 9)

Berry, 1933, p. 22.

A single rather fragmentary leaf, simple, obovate, 1.875 inches long, 0.875 inch wide, entire, tip acute; base appears to be cuneate.

In shape, size, and details of minute venation it corresponds so closely with small leaves of this species that, although it is fragmentary, the determination was made without hesitation.

In Michigan black gum is frequent in the southern half of the Lower Peninsula and extends as far north as Manistee on the Lake Michigan side (Otis, 1925; Illick, 1927). On the Lake Huron side of the state it extends as far north as Omer, in Arenac County (Dodge, 1921b, p. 17). The northern limit of *Nyssa sylvatica* in Michigan today is only about sixty miles north of the place where it grew about ten thousand years ago.

#### OLEACEAE

##### *Fraxinus* sp. (Ash)

(Pl. XVI, Figs. 1-2, 4)

Penhallow, 1898, pp. 525-529; 1900, pp. 334-339.

Fragmentary leaflets referable to this genus were abundant in the leaf bed. On the basis of shape, size, and, more especially, character of the margin and venation, these specimens resemble more closely leaflets of *Fraxinus americana* L. and *F. pennsylvanica* Marsh. than those of any other species. No diagnostic character was found which could be used to determine definitely which one of the two species was represented. The nature of the fossil florula indicates a beech-maple climax forest, and since *F. americana* is considered an abundant dominant in the beech-maple climax forest of the Lower Peninsula, with *F. pennsylvanica* present in the lowland areas (Quick, 1923, pp. 223-232), it is altogether possible that both species may be represented by these fossil specimens.

The *Fraxinus* pollen found may represent more than one species.

*Fraxinus americana* is common throughout Michigan, whereas *F. pennsylvanica* is found chiefly in the southern part of the Lower Peninsula.

##### *Fraxinus nigra* Marsh. (Black ash)

(Pl. XVI, Fig. 3)

Penhallow, 1898, pp. 527, 528; West, 1935, pp. 20-22, pl. 324, figs. 1-4; Hansen, 1948, p. 59.

A single specimen of wood from the south bank of the creek represents the only remains of black ash. Although poorly pre-

served, its structure corresponds with that of the wood of the modern species (Record, 1934, p. 124, pl. 5, fig. 2; Brown and Panshin, 1940, pp. 518-519).

*Transverse section.* — Annual rings 0.5 to 0.75 mm. wide. Ring porous. Spring vessels irregularly oval, narrowly elliptical to slitlike; arranged singly or in radial groups of two. Shriveled tyloses sometimes visible. Summer wood vessels relatively large, isolated, or in radial rows of two or three, and surrounded by wood parenchyma, which has usually not undergone as much decomposition as the fibers. The masses of parenchyma surrounding the summer wood vessels do not ever appear to be connected. Rays difficult to distinguish and study.

*Radial section.* — Vessel segments short; without spirals; end walls transverse to oblique; perforations exclusively simple. Rays homogeneous. A golden brown gummy substance was sometimes present in the vessels and is undoubtedly a decomposition product.

*Tangential section.* — Rays distorted as a result of crushing; 1 to 3 cells wide, with the majority of them biseriate; 3 to 16 cells high. Difficult to distinguish individual fibers because of decomposition and collapse of the walls.

In the present flora black ash is found throughout Michigan; it becomes more important in the northern part of the state.

#### CAPRIFOLIACEAE

##### *Sambucus canadensis* L. (Common elder)

(Pl. X, Fig. 1)

Berry, 1924, p. 20; 1933, pp. 22, 23; Hansen, 1948, p. 59.

Nutlets of the common elder were found to be very abundant in Strata 1, 2, and 3.

This species is common throughout Michigan and abundant in the locality where the fossil collection was made.

##### *Sambucus racemosa* L. (Red-berried elder)

(Pl. X, Fig. 2)

Hansen, 1948, p. 59.

Seeds of this species were distinguished from those of *Sambucus canadensis* because the surface is less rough and is composed of tiny wavy ridges, which are for the most part horizontal and parallel.

*Sambucus racemosa* is found throughout Michigan, but most abundantly in the northern part.

## COMPOSITAE

*Bidens frondosa* L. (Beggar-ticks)

(Pl. X, Fig. 6)

Berry, 1933, p. 23.

A number of achenes characteristic of this species were found in the leaf bed. Achenes 8 mm. long by 3 mm. wide; obovate-cuneate; flat; 1-nerved on either face; 2-awned; awns retrorsely barbed; only fragmentary remains of hairs present on the margins of achenes.

*Bidens frondosa* L. is of common occurrence throughout Michigan.

*Bidens laevis* (L.) BSP.

Four achenes belonging to this species were found in the leaf bed. Achenes 6 to 7 mm. long; wedge-shaped; many-nerved; 4-awned; awns retrorsely barbed; retrorsely hispid on the margins of the achenes.

In Michigan this species has been reported only in the southern part of the Lower Peninsula, where it has been found in St. Clair County (specimen in the University of Michigan Herbarium), Tuscola County (Dodge, 1921a, p. 220), Huron County (Dodge, 1911, p. 118), and the Grand Rapids region.

*Bidens cernua* L. (?)

Achene 5 mm. long; wedge-obovate; many-nerved; fragmentary remains of four awns. This specimen resembles *Bidens laevis* (L.) BSP. very closely except that it appears to have been dilated at the tip and to have been 4-angled, as in *B. cernua*. The fragmentary awns appear to have been retrorsely barbed. Since the single specimen is incomplete, the specific identity remains questionable. *B. cernua* L. is of frequent occurrence throughout the state.

## A RECONSTRUCTION OF THE FOSSIL FLORULA

At the beginning of the last or highest stage of glacial Lake Algonquin a climax forest of beech and maple flourished in the valley of Big Creek a short distance inland from the lake. Abundant



evidence of this was afforded by the thick leaf bed in Stratum 1, which was deposited during the early part of the uplift in the north. Eighty-five per cent of the deciduous leaves were found to be beech, *Fagus grandifolia* Ehrh., and sugar maple, *Acer saccharum* Marsh. Beech was represented by the greatest variety of remains, comprising leaves, seeds, fruits, bud scales, twigs, and wood, which would seem to indicate its dominance in the number of individuals. Sugar maple, represented abundantly by leaves and wood, appeared to be codominant with the beech. In all probability these two trees formed a dense, shady forest in the valley of Big Creek.

Hemlock, *Tsuga canadensis* (L.) Carr., ranked third in abundance of fossil remains. Many needles, cones, and seeds were present throughout the leaf bed and Strata 2 and 3. The abundance of hemlock remains and the fact that it is a shade-tolerant tree suggest that it was an important constituent of the forest at that time. At the present time hemlock occurs in the Lower Peninsula of Michigan in the northern consociates of the beech-maple climax association but extends south on both sides of the peninsula. On the eastern side along Lake Huron it occurs south of Forester about as far as Port Huron (Quick, 1923, p. 225).

Other important components of the forest were the American elm, *Ulmus americana* L., ash, either *Fraxinus americana* L. or *F. pennsylvanica* Marsh., or possibly both, sycamore, *Platanus occidentalis* L., and basswood, *Tilia americana* L., arranged in the order of the abundance of their fossil remains. Black birch, *Betula lenta* L., or yellow birch, *Betula lutea* Michx. f., or perhaps both, may have been present in greater numbers than the scant fossil remains suggest.

Other less important members of the forest were black ash, *Fraxinus nigra* Marsh., black gum, *Nyssa sylvatica* Marsh., hawthorn, *Crataegus* sp., and a form of *Acer saccharum* Marsh., the leaves of which resemble those of variety *Rugelii*.

The shrubs associated with this forest were the common elder, *Sambucus canadensis* L., blue beech, *Carpinus caroliniana* Walt., prickly ash, *Zanthoxylum americanum* Mill., red-osier dogwood, *Cornus stolonifera* Michx., red raspberry, *Rubus idaeus* L., a blackberry closely resembling *Rubus allegheniensis* Porter, and the red-berried elder, *Sambucus racemosa* L. *Sambucus canadensis* L. is the most abundant shrub at the present time in the beech-maple

climax association in this particular area (Quick, 1923, p. 228). Among the fossil shrubs this species also ranked first in quantity of remains, and *Carpinus caroliniana* Walt. ranked second.

In the herbaceous layer hooked crowfoot, *Ranunculus recurvatus* Poir., is the only representative of the vernal vegetation. The summer aspect of the flora showed anemone, either *Anemone cylindrica* Gray or *A. virginiana* L., swamp buttercup, *Ranunculus septentrionalis* Poir., and agrimony, *Agrimonia* sp., near the margin of the woods, and false nettle, *Boehmeria cylindrica* (L.) Sw., and wood nettle, *Laportea canadensis* (L.) Gaud., in the deep shade of the forest. The late summer and autumnal aspect of the herbaceous layer is indicated by the remains of water smartweed, *Polygonum acre* HBK., and the bur marigolds, *Bidens cernua* L., *B. frondosa* L., and *B. laevis* (L.) BSP.

Paper birch, *Betula alba* L. var. *papyrifera* (Marsh.) Spach., although not a member of the climax forest, was present in small numbers and probably grew somewhere near by in a drier situation along the sandy lake shore, as it does today.

In Strata 2 and 3, just above the leaf bed remains of *Chara* sp., *Potamogeton* sp., *Myriophyllum* sp., and shells provide evidence of a rising water level in the mouth of Big Creek as a result of continued uplift of the land in the north. These two upper layers contained abundant remains of aquatic plants which grew in the mud and shallow water at the edge of the creek and estuary. They included water plantain, *Alisma Plantago-aquatica* L., spike rush, *Eleocharis olivacea* Torr., arrowhead, *Sagittaria latifolia* Willd., one of the bur reeds, *Sparganium* sp., *Dulichium arundinaceum* (L.) Britton, and the sedges, *Carex lupulina* Muhl., *C. retrorsa* Schwein., and another which resembled in detail *C. Schweinitzii* Dewey, and a cattail, *Typha* sp. Remains of *Larix laricina* (DuRoi) Koch and *Thuja occidentalis* L. indicate swamp conditions around the estuary.

Among the species represented by macroscopic remains recovered from this old estuary only one, *Pinus Strobus* L., was characteristic of drier upland conditions. The small amount of pollen obtained from the silts of Strata 1, 2, and 3 indicate, in addition to the mesophytic forest along the creek, a drier upland habitat in which were *Quercus* sp., *Carya* sp., and two different species of *Pinus*.

It can be inferred that the area inhabited by plants the remains

of which were preserved in the silts of the old estuary was rather limited, and was probably confined to a narrow strip of land along the lake which is characterized by fertile lake clay. Back of this, in the upland, is an area characterized by a poorer type of soil formed by ground moraines and till plains, with boggy areas in the low places (Leverett and Taylor, 1915, pl. 7). The climax type of forest may have been scarce or absent in this region, which may have been covered with a forest predominating in oak and hickory, with white pine present as a relict of the earlier pine-hemlock forest.

#### CLIMATIC SIGNIFICANCE OF THE FOSSIL FLORULA

According to Antevs' estimated temperature changes during postglacial time, the temperature during the life of Lake Algonquin was lower than that prevailing today in Michigan (Antevs, 1931, pp. 2-15). No evidence has been obtained from the presence of a fossil florula composed of more than fifty genera which would indicate definitely that the climate in the vicinity of Forester during late Algonquin time was at all different from that prevailing there today. The species in the fossil forest are, for the most part, those characteristic of the beech-maple forest growing in that particular region today (Quick, 1923, p. 228). Certain species of secondary importance which are characteristic and abundant in the climax forest in the northern part of the Lower Peninsula, as, for example, *Taxus canadensis*, *Acer pennsylvanicum*, *Acer spicatum*, *Gaylussacia baccata*, *Lonicera canadensis*, and *Sambucus racemosa*, were absent in the fossil material, with the exception of *Sambucus racemosa*. This species, although prominent in the north, is found sparingly in the southern part of the state. The much greater abundance of fossil seeds of *S. canadensis* appears to indicate that it was more prominent than *S. racemosa* in the Forester region during later Algonquin time, as it is now in the modern flora.

The large amount of hemlock, also more prominent in the climax forest farther north, might be interpreted as indicating a lower temperature. But, on the other hand, hemlock is to be found reproducing itself today in a beech-maple grove within a mile of the Forester deposit. Since the deposit undoubtedly contains remains from an area of rather limited dimensions, the reasons are equally strong for not interpreting the abundant remains of this species as an indication of a lower temperature than that which occurs there today.

The abundance of *Platanus* and the presence of *Nyssa* indicate a relatively warm climate similar to that of the present. The northern limit of the range of these two species in the Lower Peninsula today is only fifty to seventy-five miles north of Forester. The occurrence of these two species during Algonquin time so near to the northern limits of their present ranges strongly indicates climatic conditions similar to those now prevailing in that vicinity.

The close proximity of the ice front, 240 to 250 miles distant, apparently had little if any effect on the climate, at least so far as the type of vegetation was concerned. All the species in the fossil flora which have a characteristically wide northern distribution may be found growing some distance south of Forester today. Upham (1895) recognized that the nearness of the margin of a continental ice sheet to a certain region would not materially affect the temperature, and he believed it to be entirely possible for a warm temperate flora and fauna to keep pace with the glacial recession.

Of the 416 species of vascular plants found growing on the narrow rim of land surrounding the continental ice cap in Greenland, Fernald (1925, pp. 245-246) says: "... 275 (67 % of the Greenland flora) occur south of the St. Lawrence or the Straits of Belle Isle, 243 of them (58½ % of the Greenland flora) being known at or near sea-level; and 100 species (24 % of the Greenland flora) occur in Massachusetts, Rhode Island or Connecticut. Furthermore, 75 species which occur in Greenland (18 % of its flora) are plants of temperate eastern America which reach their northeastern limits in America (outside of Greenland) at or near the Straits of Belle Isle."

At Mendenhall Glacier, near Juneau, Alaska, Taylor (1932, p. 387) noted that the first pioneers appeared on glacial sand 2,170 feet away from the face of the glacier, and that *Picea sitchensis* and *Tsuga heterophylla* were present with them. At a distance of 6,070 feet from the margin of the ice he found a subclimax forest composed exclusively of spruce seventy-five years old.

Cooper (1942) pointed out that the fossil coniferous forest near Minneapolis, Minnesota, described by Cooper and Foot (1932), was well established when the continental ice front was only 150 miles or less distant. And close proximity to a receding ice sheet is not prohibitive to shrub and tree growth in similar situations in Alaska, where in some places alder thicket and spruce forests grow on abla-

tion moraines that rest upon stagnant ice (1923). But he suggested caution in drawing parallels between the conditions in Alaska today with those surrounding a continental ice sheet on the interior of a continent.

In Michigan there may have been local conditions which hastened the development of a beech-maple climax forest. In the Lower Peninsula the range of many southern plants extends farther north along both the Lake Michigan and the Lake Huron shores than in the center of the state, and likewise the range of many northern plants extends farther south along the two shorelines than throughout the interior of the state. It is known that the Great Lakes tend to equalize the temperature of the land surfaces near by (Schneider, 1917, p. 1). In an ecological study of Michigan vegetation Quick (1923, p. 234) made the following statement: "The more moderate climate of the lake shores allows the northern plants to remain here uninjured by the heat of the summer, and at the same time allows a northward advance of southern species in the same regions because of the lessened severity of the winter." It is altogether possible that the same conditions prevailed during Algonquin time and that a beech-maple climax forest invaded Michigan along the eastern side of the state more rapidly than in the central part. The strip of lake clay along the eastern side of the "Thumb" (Leverett and Taylor, 1915, pl. 7) doubtless caused a more rapid development of the vegetation to the climax forest condition. The high water-holding capacity of the clay would make it possible for humus to develop rapidly and thus prepare the soil for occupancy by a mesophytic forest. The region to the north and south of Forester bordering on the lake was no doubt also characterized by the same type of forest, since the soil is generally the same.

The fossil forest indicates that optimum growing conditions had been attained during late Algonquin time in the valley of Big Creek, near Forester, Michigan, with respect to (1) moisture, (2) soil, and (3) atmospheric factors. On the basis of the evidence at hand the climate in Sanilac County at that time may be regarded as having been similar to that prevailing there today. Whether or not this forest of late Algonquin time remained unaltered by climatic fluctuations during the intervening time up to the present has not been proved. However, no significant change in type of forest vegetation

was indicated by the fossil remains in the strata of the old estuary which existed during the time of the last or highest stage of Lake Algonquin, a period of approximately four thousand years. It is significant that there is in the Forester area at the present time a climax forest similar in its component species to the fossil forest which flourished there over ten thousand years ago.

#### SUMMARY

1. A postglacial deposit in Sanilac County, near Forester, Michigan, is described.

2. The deposit was formed during the last or highest stage of glacial Lake Algonquin.

3. The deposit is of considerable antiquity and is about 10,500 years old.

4. The fossil material identified represents thirty-three families, fifty-three genera, and forty-nine species.

5. The fossil florula represents a beech-maple climax forest made up of the same plants which characterize the climax forest in the southern half of the Lower Peninsula of Michigan, rather than the climax forest of the northern part of the Lower Peninsula and in the Upper Peninsula.

6. The presence of a beech-maple climax forest during late Algonquin time indicates that optimum growing conditions had been attained in that locality with regard to (1) soil, (2) rainfall, and (3) temperature.

7. The climate is considered to have been similar to that prevailing today in Sanilac County, Michigan.

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RALEIGH, NORTH CAROLINA

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1

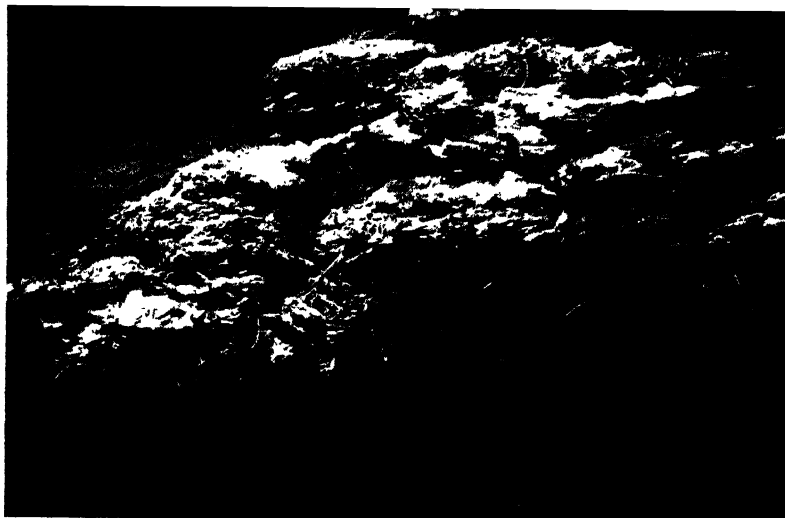


2

FIG. 1. Exposures in the north and south banks of Big Creek, near Forester, Michigan (photograph by Mr. L. A. Harris)

FIG. 2. Section exposed in the north bank of Big Creek





1



2



3

FIG. 1. Fossil leaves weathered out from Stratum 1

FIG. 2. *Thuidium delicatulum* (Hedw.) Mitt. Habit of plant.  $\times 20$

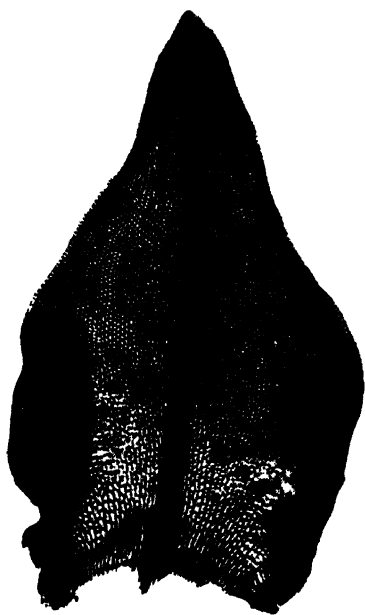
FIG. 3. *Thuidium delicatulum* (Hedw.) Mitt. Part of a single leaf.  $\times 70$

### EXPLANATION OF PLATE III

- FIG. 1. *Leucodon sciuroides* (L.) Swaegr. A single leaf.  $\times 75$   
FIG. 2. *Anomodon attenuatus* (Hedw.) Hüb. A single leaf.  $\times 75$   
FIG. 3. *Eurhynchium strigosum* (Hedw.) J. and S. Habit of plant.  $\times 30$   
FIG. 4. *Eurhynchium strigosum* (Hedw.) J. and S. A single leaf.  $\times 75$



1



2



4



## EXPLANATION OF PLATE IV

FIG. 1. *Onoclea sensibilis* L. Part of fertile frond.  $\times 1$

FIG. 2. *Tsuga canadensis* (L.) Carr. A small twig and individual needles.  $\times 1$

FIG. 3. *Tsuga canadensis* (L.) Carr. Seeds.  $\times 1$

FIG. 4. *Tsuga canadensis* (L.) Carr. Open cones.  $\times 1$

FIG. 5. *Thuja occidentalis* L. Small twigs.  $\times 1$

FIG. 6. *Thuja occidentalis* L. Open cones.  $\times 1$

FIG. 7. *Pinus Strobus* L. Lower half of an open cone.  $\times 1$

FIG. 8. *Sparganium* sp. Achenes.  $\times 4$

FIGS. 9, 11. *Potamogeton* sp. Achenes representing three species.  $\times 4$

FIG. 10. *Myriophyllum* sp. Floral leaves.  $\times 1$





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11



## EXPLANATION OF PLATE V

- FIG. 1. *Sagittaria latifolia* Willd. Achenes.  $\times 4$   
FIG. 2. *Dulichium arundinaceum* (L.) Britton. Achene.  $\times 4$   
FIG. 3. *Carex lupulina* Muhl. Achene.  $\times 4$   
FIG. 4. *Carex retrorsa* Schwein. Achenes.  $\times 4$   
FIG. 5. *Carex Schweinitzii* Dew.? Achenes, one enclosed within perigynium.  $\times 8$   
FIG. 6. *Ranunculus septentrionalis* Poir. Achene.  $\times 4$   
FIG. 7. *Anemone* sp. Achene.  $\times 4$   
FIGS. 8, 9. *Cornus stolonifera* Michx. Seeds.  $\times 4$



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## EXPLANATION OF PLATE VI

FIGS. 1 2. *Tilia americana* L. Bracts.  $\times 1$

FIG. 3. *Tilia americana* L. Fruit  $\times 1$

FIGS. 4-5. *Tilia americana* L. Fragments of leaves  $\times 1$

FIG. 6. *Carpinus caroliniana* Walt. Leaf.  $\times 1$

FIG. 7. *Carpinus caroliniana* Walt. Seed.  $\times 1$

FIGS. 8 9 *Carpinus caroliniana* Walt. Bracts  $\times 1$



## EXPLANATION OF PLATE VII

FIGS. 1-2. *Fagus grandifolia* Ehrhardt. Fruits.  $\times 1$

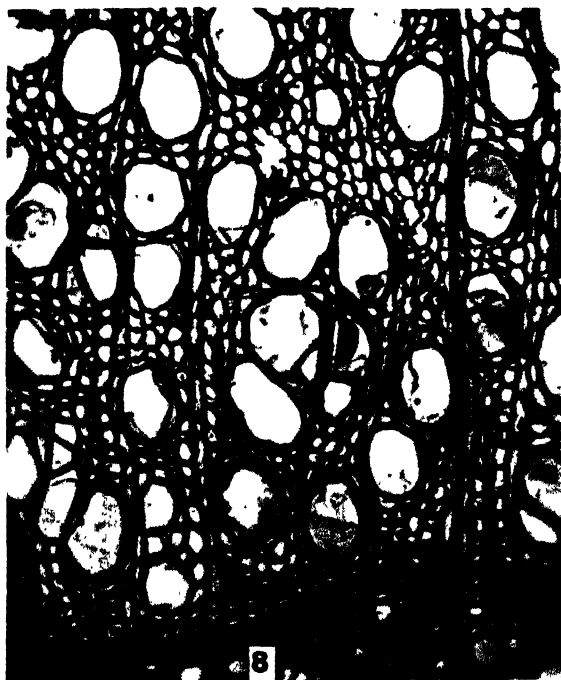
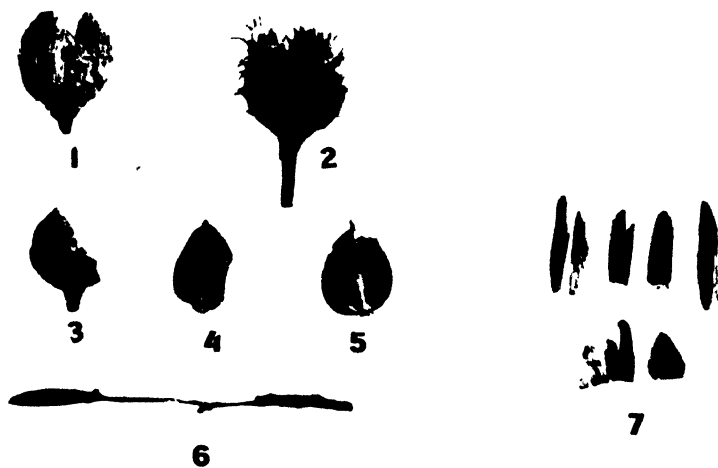
FIGS. 3-5. *Fagus grandifolia* Ehrhardt. Seeds.  $\times 1$

FIG. 6. *Fagus grandifolia* Ehrhardt. Twig.  $\times 1$

FIG. 7. *Fagus grandifolia* Ehrhardt. Bud scales.  $\times 1$

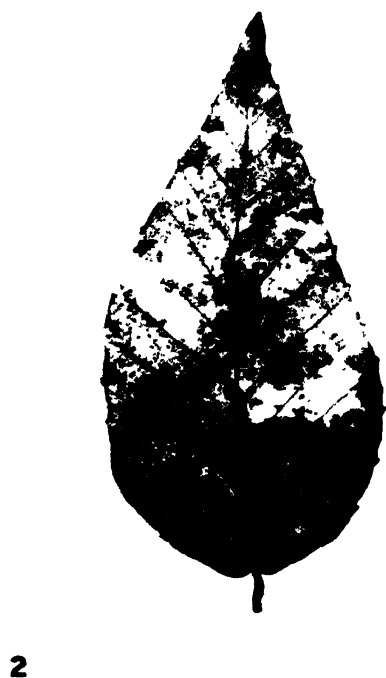
FIG. 8. *Fagus grandifolia* Ehrhardt. Transverse section of wood.  $\times 125$

FIG. 9. *Nyssa sylvatica* Marsh. Leaf.  $\times 1$









FIGS. 1-4. *Fagus grandifolia* Ehrhardt. Leaves.  $\times 1$





*Ulmus americana* L.

FIGS. 1-3. Leaves.  $\times 1$

FIG. 4. Transverse section of wood.  $\times 125$

## EXPLANATION OF PLATE X

- FIG. 1. *Sambucus canadensis* L. Seeds.  $\times 4$   
FIG. 2. *Sambucus racemosa* L. Seeds.  $\times 4$   
FIG. 3. *Rubus idaeus* L.? Seeds.  $\times 4$   
FIG. 4. *Rubus allegheniensis* Porter.? Seeds.  $\times 4$   
FIG. 5. *Vitis vulpina* L. Seed.  $\times 4$   
FIG. 6. *Bidens frondosa* L. Achene.  $\times 4$   
FIG. 7. *Zanthoxylum americanum* Mill. Thorn.  $\times 4$   
FIGS. 8-9. *Agrimonia* sp. Fruits.  $\times 4$   
FIG. 10. *Zanthoxylum americanum* Mill. Seed.  $\times 4$   
FIGS. 11-13. *Laportea canadensis* (L.) Gaud. Achenes.  $\times 6$



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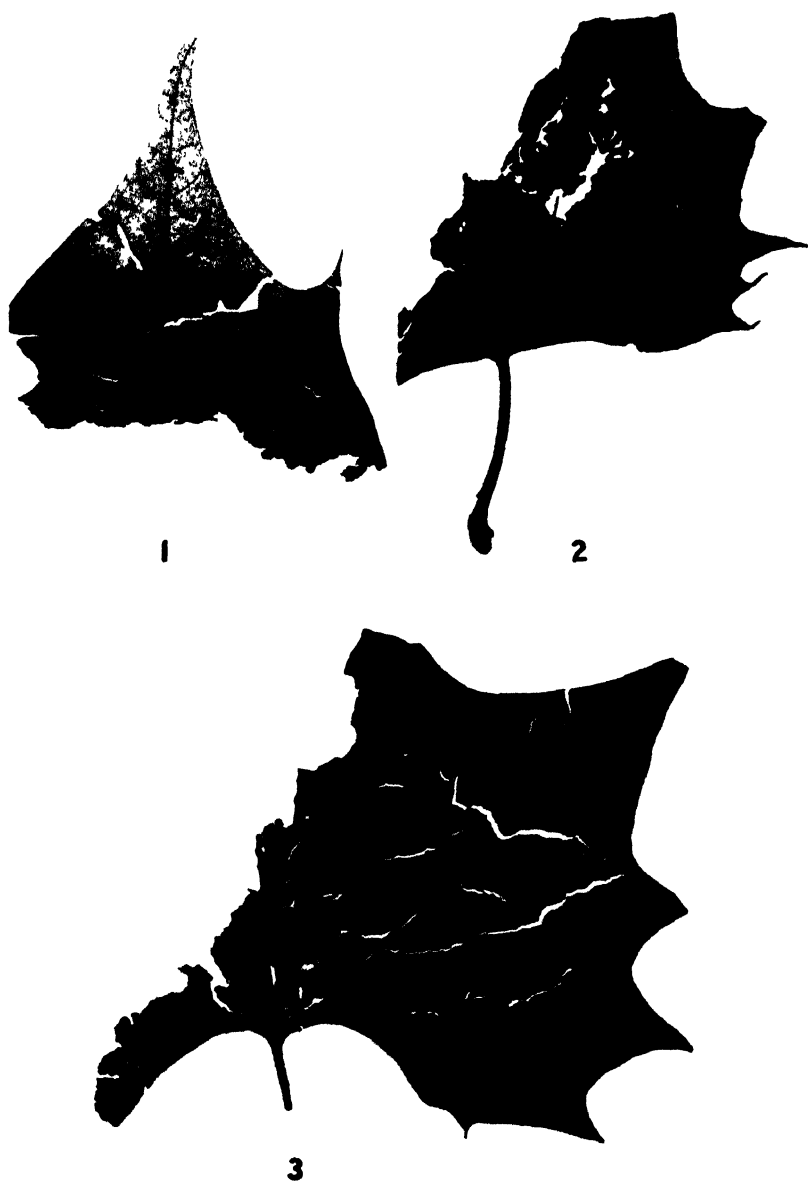


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13





FIGS. 1-3. *Platanus occidentalis* L. Leaves.  $\times 1$







2



3

- FIG. 1. *Platanus occidentalis* L. Transverse section of wood.  $\times 125$   
FIG. 2. *Crataegus* sp. Leaf.  $\times 1$   
FIG. 3. *Platanus occidentalis* L. Part of a leaf.  $\times 1$





*Acer saccharum* Marsh.  $\times 1$

FIGS. 1-2. Leaves. FIG. 3. Seed





*Acer saccharum* Marsh. Transverse section of wood.  $\times 125$





2

FIGS. 1-2. Leaves of *Acer saccharum* var. *Rugelii* Rehd. (?)  $\times 1$





FIGS. 1, 2, 4. *Fraxinus* sp. Leaflets.  $\times 1$ FIG. 3. *Fraxinus nigra* Marsh. Transverse section of wood.  $\times 125$



# FORESTRY



## SOME RESUPINATE POLYPORES FROM THE REGION OF THE GREAT LAKES. XVIII \*

DOW V. BAXTER

**F**IELD observations over much of North America and Europe indicate that practically all the resupinate polypores from the region of the Great Lakes grow elsewhere on our continent and that a large number of them occur in Europe. Among the many species common to both Europe and North America it appears that the North American specimens exhibit even wider variations in growth and structural features than do specimens found abroad. Perhaps this is because of a greater number of kinds of substrata and the more divergent environments on our continent than in Europe. It is only natural that these facts should lead to the description of a large number of species here, but it is likely that at least several of the plants are actually forms or races and do not deserve specific rank. It is for this reason that a study of the characteristics of American plants in culture is becoming increasingly important.

*Polyporus abietinus* may be cited as an example of a plant that is found on both continents and that exhibits a wide range of variation. I was unable to find our common and closely allied *Pol. pargamenus* on the aspen about Uppsala although environmental

\* Throughout the work on these monographs I am indebted to many institutions and individuals for suggestions, help, and privileges extended to me. Grants from the Horace H. Rackham School of Graduate Studies, of the University of Michigan, have greatly facilitated both the field and the laboratory studies. My appreciation is expressed particularly to the men who have accompanied me on my numerous expeditions to Alaska, the Yukon Territory, and the Northwest Territories. Much credit is due them for aiding in the collection and care of specimens and for living, at times, under rather difficult circumstances. I am under obligation to Professor T. G. Halle of Naturhistoriska Riskmuséet in Stockholm, with whom I have had the pleasure of association. Thanks are due several American institutions and scholars, also. To the authorities at the New York Botanical Garden, to the staff of the Division of Pathological and Mycological Collections of the United States Department of Agriculture, and to Professor H. H. Bartlett, of the University of Michigan, I am especially indebted.

conditions for *Pol. abietinus* and *Pol. pargamensis* in this country seem to be identical and *Pol. abietinus* was plentiful on the spruce in Sweden. At least two distinct forms of *Pol. abietinus*, however, do occur in Europe and these have received specific names under two different genera (18). The extreme morphological variants of this plant are represented chiefly by the porose form of *Pol. abietinus* (Dicks.) Fr., in the limited sense, and by forms in which teeth, or even lamellae, appear. This latter plant has been designated in Europe as *Irpex fuscoviolaceus* (Ehrenb.) Fr. In America the fungus presents many variations, and it may at first seem hopeless to try to draw distinct limits between the different forms. Interfertility between porose and other forms from America and Europe has been demonstrated, so that at least several of them must be regarded as conspecific. Robak (18) has cited an additional example; he has demonstrated that the submerged hyphae of *Trametes odorata* of Europe and *T. americana* Overh. of North America "intermingled readily," and so he regards *T. americana* as only a subspecies of *T. odorata*.

This, the eighteenth paper in the present series, represents a continuation of the study of the resupinate polypores with reference to their occurrence in the field, their distribution, and their morphological characteristics, as well as their features in culture. Two new species (*Poria herbicola* and *P. Diospyri*) and two new varieties are described.

### ***Poria herbicola* sp. nov.**

(Plate I)

Type:

*Poria herbicola* sp. nov. on soil, Ann Arbor, Michigan. Coll. Dow V. Baxter, July 15, 1945. Herb. Dow V. Baxter, Ann Arbor.

Fructificatio annua, effusa per caespites graminum et trifoliorum, 30 cm. diam., prope culmos et laminas graminum nodulosa sterilisque, alba vel albida, nondum mortua subsicca et subcoriacea, siccitate dura et ossea; marginibus fertilibus; poris 1-2 mm. (plerumque 2 mm.) longis, siccitate solum 0.5-1 mm. (vel minus); orificiis angularibus, 0.5-1 mm. diam., albis vel pallide salmonicoloribus, aetate cinerescentibus; sporis 4(5)  $\mu$  longis, 3  $\mu$  crassis; hypharum membrana tenui; hyphis vivis 4(5)  $\mu$  crassis.

Specimen typicum legit Dow V. Baxter, no. 23165, prope Ann Arbor, Michigan, Jul. 15, 1945; in herb. auctoris conservatum.

Fructification annual, effused over lawn in patches approximately 30 cm. in diameter and killing the grass, becoming nodular and sterile about grass blades, white or whitish in both fresh and dried specimens, dry and somewhat coriaceous even when fresh, drying hard and bonelike; margins becoming fertile; tubes 1–2 mm. (mostly 2 mm.) long when fresh, drying down to 0.5–1 mm. or less; mouths angular, 1 or 2 to a mm., white to “pinkish buff” when fresh, graying, when dried, to “light buff”; spores  $4(5) \times 3 \mu$ ; hyphae thin-walled, 4–5  $\mu$  in diameter, when fresh mostly 4  $\mu$ .

*Allied species.* — The habitat of this plant suggests that it might be *Poria terrestris*, or at least be related to one or more of the interpretations given that species — especially since almost any specimen found on soil has acquired that name. *P. terrestris* Pers., however, becomes brownish red upon drying, as does *P. terrestris* DC. (*Fl. fr.*, 6 : 39 = *P. mollicula* Nob. p. t. [Lloyd, *Myc. Not.*, n. 40, p. 543], non *P. terrestris* Pers. nec Bres. ex Bourdot and Galzin). The majority of the specimens under this name examined in European herbaria are brown or reddish brown and do not suggest *P. herbicola* in color upon drying. The spores of *P. terrestris* Pers. are somewhat larger, i.e.  $5-6 \times 3.5-4 \mu$  (Bourdot and Galzin). Color variations between the dried plants of other interpretations mentioned will serve as the best means of distinguishing them.

Dried specimens of *Poria herbicola* suggest *P. rancida* Bres., which also grows on fallen needles and sticks, but that species does not remain so whitish, becoming more “pinkish buff” upon drying. Furthermore, the spores of that species are  $5-7 \times 2.5-2.7 \mu$  (Bourdot and Galzin).

*Habitat.* — On soil and grass.

*Distribution.* — Michigan.

### *Poria Diospyri* sp. nov.

(Plate II)

Type:

*Poria Diospyri* on *Diospyrus virginiana*, Sand Springs, Oklahoma. Coll. Lt. Albert T. Lagemann and Dow V. Baxter, Aug. 25, 1945. Herb. Dow V. Baxter, Ann Arbor.

Fructificatio annua vel perennis, usque ad 1 m. in ligno *Diospyri virginianae* effusa; plantis annuis plerumque 2 mm. crassis, albidis vel pallide ochraceis, plantis perennibus ca. 5 mm. crassis, plerumque albidis vel subsulphureis; poris 0.5–3 mm. longis, in speciminibus vetustis plerumque 2.5 mm. longis, 2- vel 3-stratis; orificiis  $\frac{1}{8}$  vel  $\frac{1}{4}$  mm. diam., albis vel siccitate pallide luteiochraceis; sporis 3–4  $\mu$  longis, 2–3  $\mu$  crassis, plerumque  $3 \times 4 \mu$ ; hyphis hyalinis saepe incrustatis, septatis vel haud septatis, diam. 3–5.5  $\mu$ .

Specimen typicum legerunt Lt. Albert T. Lagemann et Dow V. Baxter, no. 23166, prope Sand Springs, Oklahoma, Aug. 25, 1945; in herb. auctoris conservatum.

Fructification annual or perennial, effused for as much as 1 meter; one-year-old plants mostly about 2 mm. thick, whitish to tan, older specimens approximately 5 mm. thick, mostly white or slightly sulphureous; tubes 0.5–3 mm. long, in old specimens usually 2.5 mm. long, in two or three layers; mouths mostly 5–6 to a mm., white, drying "ivory-yellow" to "cream-buff" to "chamois"; spores (2)3  $\times$  (3)4  $\mu$ ; hyphae hyaline, often incrustated, septate or nonseptate, 3–5.5  $\mu$  in diameter.

*Allied species.* — Annual specimens of *Poria Diospyri* suggest some of the many growth forms of *P. versipora* because of their color and texture, especially since it is common for *P. versipora* to live through the winter. *P. Diospyri* suggests *P. versipora* only in annual growth forms, however, for, with age, it becomes a thick plant, the mouths, if not whitish, are more brown than "cinnamon-buff" and are much smaller (5–6 to a mm.) than those of *P. versipora* (1–3 to a mm.), and the dissepiments are not dentate. Older specimens of *P. Diospyri* are also somewhat chalky in appearance, a feature that is not characteristic of *P. versipora*.

Differences between thin and older forms are great enough to make them appear at first glance to be two species. The plants studied, however, were collected on the same log, and the development of the old from the younger forms was traced in the field. Thicker and older specimens resemble *Poria xantha crassa* much more than they do *P. versipora*. The mouths of the tubes in both porias are of small diameter. Furthermore, the color in mature specimens of *P. Diospyri* may be sulphureous ("ivory-yellow")



as in *P. xantha crassa*. Chalky appearance and checking upon drying are characteristic of both plants. These porias may be separated by their spores, which are allantoid,  $4-6 \times 1-1.5 \mu$ , in *P. xantha crassa* and  $3 \times 4 \mu$  in *P. Diospyri*.

*Habitat.* — *Diospyrus virginiana*.

*Distribution.* — Oklahoma.

### **Fomes robustus Taxodii** var. nov.

(Plate III)

Type:

*Fomesrobustus Taxodii* var. nov. on *Taxodium distichum*, Okeefinokee swamp, Georgia. Herb. Dow V. Baxter, Ann Arbor.

Fructificatio partim perennis, in areis 1-4 persistens et incrementis stratosis annuis gradatim minoribus accrescens, plerumque adnata sed saepe ad marginem separans; marginibus primum 1-2 mm. latis, rosaceibrunneis, aetate fertilibus, crassioribus, subluteibrunneis; subiculo tenui, plerumque minus quam 1 mm. crasso; strato composito, tubuloso usque ad 3 cm. crasso, sed saepe minus quam 1 cm. et eo Poriae typicae lignosae simili modo "generis" Fomitiporiae; tubis annuis, 2-4 mm. longis, obvie stratosi, ore subcircularibus, crassis, integris, 5-7 in uno mm., ochraceis vel brunneis; sporis globosis 5-8  $\mu$  diam.; hyphis subiculi brunneis, simplicibus, non septatis, 2-5-3.5  $\mu$  diam., setae desunt.

Specimen typicum legit D. V. Baxter in ligno *Taxodii distichi*, in locis lacustribus "Okeefinokee Swamp," Georgia; conservatum in herbario auctoris.

Fructification perennial in small patches, mostly adnate, but often separating at the margins upon drying; margin at first 1-2 mm. wide, "Saccardo's umber," becoming fertile and, often, thick and "Verona brown"; subiculum thin, mostly less than 1 mm. thick; tube layers reaching a thickness of about 3 cm., but often less than 1 cm. thick, and resembling those of a typical non-woody poria as much as do the tube layers of perennial forms that have been classed as Fomitiporia; tubes 2-4 mm. long each season, rather distinctly stratified; mouths subcircular, thick-walled, entire, averaging 5-7 to a mm., "clay-color," "buckthorn-brown," or "raw sienna"; spores globose, 5-8  $\mu$  in diameter;

hyphae of subiculum brown, simple, nonseptate, 2.5–3.5  $\mu$  in diameter; no setae.

*Allied species.* — The new variety, which grows on bald cypress, differs chiefly in size from *Fomes robustus tsuginus* (Peck) Overh., which is very common on *Tsuga canadensis* and *T. heterophylla* and much less abundant on western species of *Abies*. *F. robustus Taxodii* does not cover large areas of log surface and the tubes are commonly in one layer, that is, the plant is often less than 0.5 cm. thick and never becomes so multilayered as does the species. In this form it more nearly resembles *Fuscoporia juniperina* Murr. than it does the allied variety *tsugina*. It is to be distinguished from *Fuscoporia juniperina* by its orbicular type of growth and by its greater thickness at maturity. The receding type of growth exhibited in old specimens of the variety *Taxodii* is not evident in *Fuscoporia juniperina*. The spores of *Fuscoporia juniperina* are 5–6  $\mu$  and are therefore smaller, and setae occur in that species, but not in *Fomes robustus tsugina*. Fruiting bodies of the variety *Taxodii* do not appear at the junction of a branch, as those of the species usually do, and the variety does not occur on standing trees.

*Habitat.* — *Taxodium distichum*.

*Distribution.* — Georgia.

*Decay.* — *Fomes robustus Taxodii* produces a white rot in cypress. The decayed wood separates into sheets.

*Polyporus abietinus* (Dicks.) Fr., Syst. Myc., 1: 370. 1821

(Plate IV)

*Boletus abietinus* Dicks., Pl. Crypt. Brit., 3: 21. 1793.

*Boletus incarnatus* Schum., Enum. Pl. Saell., 2: 391. 1803.

*Polyporus parvulus* Schw., Trans. Am. Phil. Soc., II, 4: 157. 1832.

*Polystictus abietinus* (Dicks.) Cooke, Grevillea, 14: 84. 1886.

*Coriolus abietinus* (Dicks.) Quél. Ench. Fung., p. 175. 1886.

*Poria caesia* Karst. in Sacc., Syll. Fung., 6: 305. 1888.

*Polystictus pusio* Sacc. & Cub. in Sacc., Syll. Fung., 6: 265. 1888.

*Daedalea unicolor violacea* Clements, Crypt. Form. Colo., no. 170. 1905.

*Lenzites Abietis* Lloyd, Mycol. Notes, 6: 909, f. 1607. 1920.

*Hirschioporus abietinus* (Dicks.) Donk, Mededeelingen uit het Botanisch Museum en Herbarium der Rijksuniversiteit te Utrecht, 9: 168. 1933.

Important specimen:

*Physiporus caesia* Karst. on *Abies*. Herb. of Bresadola, Stockholm.

## Forms

- f. *fuscoviolaceus* (*Irpex fuscoviolaceus* [Ehrenb. ex Fr.] Fr.). This form is generally regarded as irpicoid, but is sometimes described as including even lamellate types. It is here restricted to irpicoid plants. The form is otherwise similar to the species and has been shown in cultures (18) to be conspecific with porose forms.
- f. *Abietis* (Lloyd) Overh. This form has a lamellate hymenium and does not include irpicoid plants. American lamellate plants have been shown to be conspecific with porose collections by Robak (18).
- f. *Thelephoroides* forma nov. (Pl. VI. This form is described on p. 203.)

Fructification thin, coriaceous, sessile, effused-reflexed or resupinate, but usually reflexed at margins at least; surface zonate, tomentose-strigose, white or gray, "vinaceous buff," or "avellaneous"; margin thin, undulating; context pallid, less than 1 mm. in width; tubes less than 1 mm. long; mouths at first "livid purple," becoming "vinaceous fawn" to "vinaceous buff" or "avellaneous," 2-3 to a mm., subround or angular, becoming sinuous, irpicoid, or even lamellate; basidia 4-7  $\mu$  broad; spores smooth, hyaline, subcylindric to allantoid, 6-9  $\times$  2-3  $\mu$ ; hyphae 2-4  $\mu$  in diameter; cystidia numerous or rare, 4-9  $\mu$  in diameter, sometimes projecting up to 20  $\mu$  or more, hyaline, smooth or incrustated at the apex.

*Allied species.* — *Polyporus abietinus* is represented by porose and lamellate forms. Some of these have been described as species (see Pl. V). Those that have teeth or lamellae, for example, are often known under the name *Irpex fuscoviolaceus* (Ehrenb. ex Fr.) Fr. In America the lamellate form has been designated as *Pol. abietinus Abietis* (Lloyd) Overh., also. Irpicoid or lamellate forms (*Irpex fuscoviolaceus*) are regarded by Robak (18) as "subspecies." His work with both American and Norwegian porose, irpicoid, and lamellate forms in culture indicates that they are, at any rate, conspecific.

*Polyporus pargamensis* Fr. is one of the most common of the American species allied to *Pol. abietinus*. Microscopic features are, for the most part, similar in the two plants, and the spores fail to furnish any means of distinguishing the two polypores.

It is pointed out by Rhoads (16) that in the usual hydroid form *Pol. pargamensis* cystidia are of infrequent occurrence, whereas *Pol. abietinus* is characterized by abundant, prominent capitate cystidia. But porose forms of *Pol. pargamensis* have the same type of cystidia as *Pol. abietinus*, so that this character cannot be used to separate the two species. It is generally possible, however, to distinguish between the two plants by the difference in size. The fruiting body of *Pol. abietinus* seldom exceeds 3 cm. in length, whereas *Pol. pargamensis* is larger, reaching 7 cm. *Pol. pargamensis*, furthermore, is usually fan-shaped and is attached to the substratum by a narrow stalklike attenuation. The fruiting bodies of *Pol. abietinus* may occasionally be fan-shaped, but the place of attachment is broader (19) and never stalklike. Distinctions may usually, but not always, be based on the fact that *Pol. abietinus* is generally found on coniferous wood, whereas *Pol. pargamensis* ordinarily grows on wood of dicotyledonous tree species. In the region of the Great Lakes aspen is the most common substratum of *Pol. pargamensis*. In the spruce and pine forests of Sweden where aspen is present *Pol. abietinus* occurs abundantly, but I have never found either it or *Pol. pargamensis* on aspen there.

The hymenium of *Polyporus subchartaceus* may be purplish, and since the spores and cystidia are the same as in *Pol. abietinus* and the fungus is usually found on aspen and cottonwood, *Pol. subchartaceus* should be mentioned in a discussion of either *Pol. abietinus* or *Pol. pargamensis*. The thickness of the pileus, which is greater than 4 mm., may be used to separate *Pol. subchartaceus* from *Pol. abietinus*. The pileus is less than 4 mm. thick in *Pol. abietinus*, as well as in *Pol. pargamensis*.

Names such as *Lenzites abietina* and *L. striata* appearing in the literature may lead to some confusion, especially since the genus *Lenzites* includes lamellate plants. These are, however, related to the brown *Lenzites saepiaria*.

*Habitat.* — *Abies amabilis*, *A. arizonica*, *A. balsamea*, *A. concolor*, *A. grandis*, *A. lasiocarpa*, *A. magnifica*, *Chamaecyparis thyoides*, *Cupressus macrocarpa*, *Larix laricina*, *L. Lyallii*, *L. occidentalis*, *Libocedrus decurrens*, *Picea Engelmannii*, *P. glauca*, *P. mariana*, *P. sitchensis*, *P. rubra*, *Pinus attenuata*, *P. Banksiana*, *P. contorta*, *P. Coulteri*, *P. echinata*, *P. edulis*, *P. flexilis*, *P. glabra*,

*P. lariceo-austriaca*, *P. monticola*, *P. palustris*, *P. ponderosa*, *P. radiata*, *P. resinosa*, *P. rigida*, *P. Sabiniana*, *P. silvestris*, *P. Strobilus*, *P. virginiana*, *Populus trichocarpa*, *Prunus emarginata*,<sup>1</sup> *Pseudotsuga macrocarpa*, *P. taxifolia*, *Sequoia sempervirens*, *Sorbus americana*, *Thuja occidentalis*, *T. plicata*, *Tsuga canadensis*, *T. heterophylla*, *T. Mertensiana*.

**Distribution.** — Alberta, British Columbia, Labrador, Manitoba, New Brunswick, Newfoundland, Northwest Territories, Nova Scotia, Ontario, Prince Edward Island, Quebec, Saskatchewan, Yukon Territory; Alaska, Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Idaho, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Jersey, New Hampshire, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming.

**Occurrence.** — *Polyporus abietinus* is one of the most widely distributed polypores on conifers throughout the continent. Many new geographic records of the occurrence of this fungus are reported here, especially for the territories and provinces of Canada. Authentic accounts of its presence in Illinois, North Dakota, and Oklahoma are lacking. A few records of this conifer-inhabiting fungus on dicotyledonous woods exist. A collection is reported (22), for example, on *Populus trichocarpa*. The fungus is one of the first of the polypores to attack fire-killed, dead, or fallen conifers and is especially common on pulpwood and lumber, causing decay during storage.

Fruiting bodies may appear as early as two months after a tree has been felled. In regard to white-pine slash in New England, Spaulding (21) reports that rot of sapwood by this fungus becomes apparent in the larger pieces of slash, which have thick layers of sapwood, during the second year. Sap rot caused by this species is well advanced in New England white-pine slash by the fifth year. *Polyporus abietinus* is next in frequency of occurrence to *Lenzites saepiaria* (21), which probably rots more New England white-pine slash than any other fungus.

<sup>1</sup> Record furnished by Dr. Ruth Macrae, of the Central Experiment Farm, Ottawa, Canada, who confirmed the identity by pairing cultures.

*Polyporus abietinus* attacks only partly shaded slash, and fruits commonly on the lower sides of the rotted limbs. It requires more moisture in the wood than *Lenzites saepiaria*. In other sections of the continent, especially where rainfall is abundant, as in the coastal forests of southeastern Alaska, decay caused by *Pol. abietinus* may be limited by too much moisture in the shade, and in such regions the fungus is often found on exposed slash off the ground or on standing snags and dead trees. Sap rot of *Pinus ponderosa* in Klamath County, Oregon, appeared principally in the second season after cutting, as did decay in slash of *Pinus Strobus* (Boyce, 4).

In fire-killed West Coast Douglas fir, this fungus is said by Kimmey and Furniss (14) to be the most important species producing decay only in the sapwood, for it causes more than fifty per cent of the decay in that type of wood. *Fomes pinicola* is regarded as the most significant fungus producing decay in both sapwood and heartwood. Nevertheless, it is emphasized that *Polyporus abietinus* probably causes the most loss to owners of old-growth fire-killed Douglas fir, for it is the source of the principal decay in trees of this type for the first five to ten years, and much timber of this kind is salvaged during that time.

Boyce (5) likewise reports, in his studies of the deterioration of wind-thrown timber on the Olympic Peninsula, Washington, that *Polyporus abietinus* attacked the greatest number of trees, but he emphasizes that the greatest total loss through decay was caused by *Fomes pinicola* and the next greatest by *F. applanatus*. This is explained by the fact that the wood attacked by *Pol. abietinus* is usually confined to the outer one-half inch of sapwood. Boyce points out that the record of fruiting bodies gives an idea of the relative abundance of a fungus, but the true measure of its importance is the amount of decay it causes. (It should be added that the importance of a fungus is proportionate to the amount of decay in reference to the specific type of product to be manufactured from the timber.) Deterioration in Douglas fir is reported as only 1.3 per cent (board measure) of the total decay; in Sitka spruce, 4.8 per cent; in silver fir, 3.0 per cent; and in western hemlock, 1.4 per cent.

*Cultures.* — Isolated on *Picea glauca*, from Healy, Alaska. The "light-buff" mycelium forms a thin mat that scarcely envelops

either white-pine or red-gum blocks in one-year-old cultures. The pink so evident in the hymenium of growing specimens in nature was not apparent in this isolate. No pores formed on any of the wood-block cultures. In Norwegian cultures Robak (18) reports that he, too, has failed to observe hymenial formation of *Polyporus abietinus*. Cartwright and Findlay (8) mention one culture that formed pores on malt agar, and Raestad (15) observed porose or irpicoid hymenia on the same medium, but reported them much more frequently in cultures of the form *fuscoviolaceus*. The hymenia observed by these investigators had the purple color characteristic of that developed by plants in nature.

Cultures of the Alaskan isolate most nearly correspond to those of *Poria anceirina* isolated from *Populus balsamifera*, Moose Pass, Alaska. Both fungi exhibit thin, "light-buff" mycelial mats that scarcely cover either red-gum or white-pine wood blocks in one-year-old cultures. The radiating growth habit of the mycelium in *Polyporus abietinus* as it spreads over the blocks is distinctive.

The optimum temperature for growth of both American and European isolates is about 27° C. Humphrey and Siggers (13) report that a Wisconsin isolate (optimum temperature 28° C.) falls in their intermediate-temperature group, i.e. that with an optimum between 24° and 32° C. The inhibiting point is given as 38° C. Robak (18) places *Polyporus abietinus* in the group of fungi having a moderate to slow growth at room temperature, a grouping that would include the Michigan (Alaskan) isolate. Growth in Norwegian cultures is reported to accelerate with temperature increases to about 25°–26° C. Temperature responses have been used to separate *Pol. abietinus* from the allied *Pol. pargamensis*. Snell and others (20) find that the results in an effort to distinguish these two species by such features were not so striking as those obtained for *Trametes odorata* and *Lenzites saepiaria*, but they were sufficiently varied to provide a temperature differential.

The Alaskan isolate grows equally well in the light and the dark. Its mycelium has no distinctive odor in cultures on malt-extract medium. In fresh cultures the hyphae branch characteristically at very acute angles, thus producing their regular,

radiating arrangement. In older cultures this feature is obliterated, as reported for European cultures (18). Aerial hyphae are 3–5  $\mu$ , mostly 3  $\mu$ , in width. Conspicuous clamp connections appear commonly on submerged and other hyphae. Swellings resembling chlamydospores are present.

Robak (18) studied the growth rate of *Polyporus abietinus* in various media containing different forms of nitrogen, as well as carbohydrates. He obtained the slowest growth on  $\text{NH}_4\text{NO}_2$  and  $(\text{NH}_4)_2\text{SO}_4$ ; the most rapid growth was obtained with urea as the source of nitrogen, the next most rapid with  $\text{NaNO}_3$ , glycolcol, and the next with asparagine. Growth on peptone media was almost uniformly slower than on the last three chemicals mentioned.

Variable results were obtained by Robak on different sugars, but strikingly slow or scanty growth was observed on xylose, galactose, and lactose.

*Polyporus abietinus* gives a strong positive reaction to tannic acid medium. It discolors aniline blue added to the agar (18). Like the Alaskan isolate grown on red-gum and white-pine wood, cultures on blocks of Scotch pine and Norway spruce spread slowly over the wood (18). Robak (18) reports the advance of a conspicuous red-brown stain paralleling the progress of the mycelium. This discoloration may be noticed to some extent in white-pine blocks, also. It resembles to a certain degree the secondary stain observed in blocks infected with *Stereum sanguinolentum*, but it is not so reddish and, when the material is dry, it is slightly more yellow-brown. The occurrence is not preceded by any other color. In the stage at which the white areas occur, the brown color has disappeared.

Using five different isolates of *Polyporus abietinus* in Norway-spruce sawdust cultures sterilized at 50° C. for six months, Robak found them to have caused losses of from 2.25 per cent to 5.25 per cent, dry weight. The average loss per strain varied between 2.6 and 4.72 per cent. In block cultures the losses were small, but it was shown that this species was able to bring about late stages of decay, at least locally, within six months.

This fungus produces more kinds of enzymes than have been reported for other wood-destroying fungi with the exception of



*Lenzites saepiaria*. Fifteen of the more common hydrolytic enzymes are produced (10): emulsin, cellulose, ligninase, amylase, sucrase, maltase, inulase, pectinase, tanninase, pepsin, trypsin, erepsin, urease, asparaginase, and lipase. Four of the more common oxidizing enzymes occur, namely, oxygenase, peroxidase, laccase, and catalase. *Polyporus abietinus* (along with *L. saepiaria*) secretes several enzymes not formed by species of such heartwood-destroying fungi as *Pol. sulphureus* and *Echinodontium tinctorium*, or by the highly specialized cambium attacking *Armillaria mellea*.

*Sexuality*. — Monosporous mycelia of different forms of *Polyporus abietinus* have been paired. Norwegian porose and irpicoid forms have been found (18) to be intersterile. Furthermore, monosporous mycelia from a porose Canadian sporophore reacted with Norwegian "Irpex" mycelia by forming clamp connections with them. On the basis of such criteria, the forms in question may be considered conspecific (18).

The common American porose form of *Polyporus abietinus* exhibits tetrapolar segregation, whereas the American irpicoid (or lamellate) form has bipolar segregation, according to Robak (18), reporting Macrae's Canadian work. Robak states further, "in spite of this, the last named form has copulated with Norwegian monospore mycelia." The common porose form of *Pol. abietinus* in Norway also exhibits tetrapolar segregation of sexes, according to Robak (18), and Raestad (15) has shown that the form *fuscoviolaceus* is similar in this respect.

*Decay*. — *Polyporus abietinus* causes one of the most common sap rots of dead coniferous wood. It appears within two or three years after the death of the tree and produces a "pitted" white rot. The first evidence of decay is a faint yellowish or tan discoloration accompanied by a softening of the wood. Later, small white areas or "pockets" appear; these may or may not be filled with whitish fibers. Narrow strips of apparently sound wood remain between the pockets. Often when the cavities are confined to one plane a ring-scale condition appears. The rotted wood in the final stage of decay is spongy. No zone lines are caused by the fungus in the wood.

*Polyporus abietinus* utilizes either cellulose or isolated lignin as a source of nutrition, but cellulose is a better source than lignin.

Nitrogenous materials are of more importance in the growth of the fungus on lignin than on cellulose (11).

Analyses by Garren (12) of results of decay in loblolly-pine sapwood indicate that both moisture content and specific gravity of the wood are significant in determining the rate of decay by *Polyporus abietinus*. Although the fact that moisture is conducive to decay is generally accepted, there has been some question regarding specific gravity as an index of durability. It seems that the higher the specific gravity of a piece of loblolly-pine sapwood, the more resistant it will be to decay by *Pol. abietinus*.

*Reaction to chemicals.* — The resistance of *Polyporus abietinus* to sodium fluoride has been tested by Richards (17). It was found that this species was next to the least resistant of a group of several wood-rotting fungi of which *Poria incrassata* is the least resistant and *Lenzites trabea* the most resistant. The fungi in this group, arranged in order of increasing resistance, are: *Poria incrassata*, *Polyporus abietinus*, *Pol. versicolor*, *Fomes roseus*, *F. pinicola*, *F. subroseus*, *L. saepiararia*, *Polystictus hirsutus*, *F. Pini Abietis*, *F. annosus* (culture now identified as *Irpex tulipifera*), and *L. trabea*.

### ***Polyporus abietinus* forma *fuscoviolaceus* comb. nov.**

*Irpex (Sistotrema) violaceus* Pers., Syn., p. 551. 1801.

*Irpex fuscoviolaceus* Fr. in El., Hym. Eur., p. 620. 1874.

Important specimen studied:

*Irpex fuscoviolaceus* (Shrad.) Fr., Bresadola Herbarium, Rijksmuseum, Stockholm.

Fructification resupinate, but usually with a slightly reflexed fimbriate margin, or, if not resupinate, having fruiting bodies, small, imbricate, slightly pubescent, white or gray; hymenium purple or violet, mostly in the form of gills, about 1-2 to a mm.; basidia  $15-24 \times 4-6.5 \mu$ ; spores hyaline, cylindrical or allantoid,  $6.5-8 \times 2.5-3.5 \mu$ ; cystidia mostly  $18-25 \times 5-7 \mu$ ; hyphae  $3-7 \mu$  in diameter (Bourdot and Galzin, in part).

*Habitat.* — Coniferous wood.

**Polyporus abietinus forma thelephoroides forma nov.**

(Plate VI)

Type:

*Polyporus abietinus* var. *thelephoroides* on coniferous wood, Lake Quinault, Washington. Collected by C. H. Kauffman in 1925. Herb. Dow V. Baxter, Ann Arbor.

Fructificatio (marginibus inclusis) resupinata, annua, areas circulares confluentes effusasque ca. 15 cm. diam. formans, colore atrogriseas vel atrocaeruleas; margine tenui, simili Thelephorae, pallide brunneigriseo, ca. 1 mm. lato, aetate fertili; subiculo minus quam 1 mm. lato sed distincto, pallide griseicinnamomeo; poris 0.5–2 mm. longis, plerumque 1.5 mm. longis, orificiis angularibus demum laceratis,  $\frac{1}{3}$  mm. diam., rosacei- vel caeruleigriseis (in vivo), colore in statu exsiccato vel similibus vel atre grisei-brunneis vel obscure nigriviolaceis vel atrogriseis. basidiis 4-sporis; sporis allantoideis, 5–6  $\mu$  longis, 2  $\mu$  crassis; infibulationibus haud raris. Habitat in ligno coniferarum, prope Lacum Quinault, Washington.

Fructification entirely resupinate, even margins largely appressed, annual, in orbicular patches that become confluent and effused for 15 cm. or more, slate-gray or bluish when fresh; margin thin, resembling that of the genus Thelephora, "drab gray" or "pale brownish drab," mostly about 1 mm. wide, becoming fertile in age; subiculum less than 0.3 mm. wide, but distinct, "light cinnamon-drab"; tubes 0.5–2 mm., mostly 1.5 mm., long; mouths when fresh pinkish or bluish gray, i.e. "pale brownish drab" to "brownish drab" and retaining the colors in herbarium material or becoming "dark grayish brown" to "dull violet-black" or "deep neutral gray," angular, becoming somewhat fringed, 1–3, mostly 2, to a mm.; basidia 4-spored, spores allantoid, 5–6  $\times$  2  $\mu$ ; cystidia capitate incrustated or not incrustated, projecting up to 10  $\mu$ ; hyphae hyaline, occasionally branched and septate, 2–4, mostly 3–4,  $\mu$  in diameter; clamp connections present.

*Allied species.* — This plant, unlike a great many collections of resupinate specimens of *Polyporus abietinus*, has a margin appressed to such an extent that it is readily mistaken for a species of the genus *Poria*. Because of the pinkish-violet color of the margin, Kauffman, according to his field notes, was reminded of

*Poria semitincta*. The general color of the plant is a dark blue, however, and not whitish as in that species. I can see no resemblance to *P. semitincta*, but can readily understand why Kauffman thought of the genus *Poria*, especially since the margins are adnate. Microscopic examination shows that this variety resembles representatives of the Thelephoraceae in the habit of growth and the color. The pores, however, are distinct. The variety is corky enough not to be readily confused with *P. purpurea* and species allied to it.

*Habitat*. — On coniferous wood.

*Distribution*. — Washington.

*Poria bombycina* (Fr.) Cooke, Hym. Eur., p. 575. 1874

(Plate VII, Figures 1-2)

*Polyporus hians* Karst., Fungi Fenniae Exic. 619, ex Bourdot and Galzin, Hyménomycètes de France, 1927.

Important specimen studied:

*Polyporus hians* Karst. ex Herb. Karsten on pine, Mustiala. Herb. Bresadola, Stockholm.

Fructification annual, appearing in small patches up to about 4 or 5 cm. in width, soft, whitish at first but becoming tawny, mostly mycelioid; margin byssoid; pores forming at first as depressions in the mycelium, thin, developing into tubes up to 1 mm. long; mouths mostly 1-2 to a mm., angular; basidia  $24-30 \times 7-8 \mu$  (Bourdot and Galzin); spores ellipsoid,  $6-7.5 \times 4.5-5 \mu$ ; hyphae mostly  $2-4 \mu$  in diameter, clamp connections present; no cystidia.

*Allied species*. — This plant looks much like a weathered specimen of *Poria sinuosa*, but it is a softer species. European specimens do not resemble the rhizomorphic *P. Vaillantii*, as is suggested in American literature of plants of this continent.

*Habitat*. — *Abies grandis*, *Larix occidentalis*, *Picea glauca*, *Pinus contorta*, *Pseudotsuga taxifolia*.

*Distribution*. — Newfoundland, Ontario, Yukon Territory; Alaska, Idaho, Montana, New Hampshire, New York, Washington, West Virginia.

*Remarks*. — The English concept of this species, as reported by Rea in *British Basidiomycetae*, corresponds to the description presented here.

*Fomes connatus* (Weinm.) Gill., Champ. Fr., 1: 684. 1878

(Plate VIII)

*Boletus populinus* Schum., Enum. Pl. Saell., 2: 384. 1803.*Poria obducens* Pers., Myc. Eur., 2: 104. 1825.*Polyporus connatus* Weinm., Fl. Ross., p. 332, 1836, non *Polyporus connatus* Schw., 1832.*Polyporus connatus* Fr., Epicr. Myc., p. 472. 1838.*Fomes populinus* (Schum.) Cooke, Grevillea, 14: 20. 1885.*Fomes Meliae* (Underw.) Murr., Bull. Torrey Bot. Club, 30: 232. 1903.*Fomes ozyporus* Sauter ex Lloyd in Synopsis of the Genus *Fomes* (Cincinnati), 283. 1915.

Fructification perennial, sessile, convex,  $2-10 \times 3-15 \times 0.5-4$  cm., imbricated or rarely resupinate, surface white or "cinnamon-buff" to "light grayish olive" in herbarium specimens, never rimose with age; usually becoming covered with moss and algae; context white, or whitish, drying to "cinnamon-buff," soft, corky, 0.3-4 cm., mostly less than 2 cm., thick; tubes distinctly stratified, 2-5 mm., mostly about 3 mm., long each season; mouths white to yellowish, glistening when fresh, drying to "clay-color," "pinkish buff," or even "sayal-brown"; spores hyaline, smooth, ellipsoid to globose,  $4-5 \times 3.5-4 \mu$ ; cystidia none or rare, capitate or club-shaped,  $3 \mu$  in diameter (Lowe); hyphae seldom branched, 2-4  $\mu$  in diameter.

*Allied species.* — The resupinate forms of this fungus usually occur in the frost cracks and wood cavities of the maple. It is easy to find states intermediate between the resupinate and the typical fructification. The resupinate form has been termed *Poria obducens* Pers. There are no closely allied species. Because the fruiting body is not woody, *Fomes connatus* might suggest, superficially, a species of *Polyporus*, but it can be readily separated upon examination, since the tubes are distinctly stratified.

*Habitat.* — *Acer dasycarpum lutescens*, *A. macrophyllum*, *A. Negundo*, *A. rubrum*, *A. saccharinum*, *A. saccharum*, *Aesculus Hippocastanum*, *A. octandra*, *Betula lulea*, *Carpinus caroliniana*, *Carya glabra*, *Cornus florida*, *Fagus grandifolia*, *Fraxinus americana*, *Gleditsia triacanthos*, *Halesia carolina*, *Hicoria* sp., *Liquidambar styraciflua*, *Nyssa sylvatica*, *Ostrya virginiana*, *Quercus alba*, *Q. Prinus*, *Sambucus* sp., *Ulmus americana*, *U. fulva*.

*Distribution.* — British Columbia, Manitoba, New Brunswick, Nova Scotia, Ontario, Prince Edward Island, Quebec; Alabama,

Arkansas, Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Pennsylvania, Rhode Island, South Dakota, Tennessee, Vermont, Virginia, West Virginia, Wisconsin.

*Occurrence.* — This fungus attacks a number of hardwoods, but it is of economic importance only on sugar maple. Red maple is attacked fully as much as sugar maple. In general, *Fomes connatus* appears to increase in abundance as the host tree approaches the northern limits of its distribution. In Minnesota, for instance, the woodlands in which maple is an important component of the forest are considerably poorer because of *F. connatus* (and, often, other fungi) than are many maple forests of Michigan. This is also true of sections of Ontario, where the maple may be exceedingly defective. The fungus is rare, however, or is not present at all in scattered maple trees at the very limits of distribution and under peculiar local conditions. It appears abundantly in Nova Scotia, but in Newfoundland the relatively few maples, perhaps because of their scarcity, are free from the fungus. As a matter of fact, in spite of persistent search, no specimens of *F. connatus* have been collected in Newfoundland.

*Cultures.* — Isolated from *Acer saccharum*, Michigan (tissue culture). It has been my experience, and also that of Campbell (6), that isolations from tissues are extremely difficult to obtain because the soft, watery sporophores are contaminated, even when young, by other fungi and bacteria. Campbell reports that the fungus finds conditions on agar media unfavorable and so makes slow growth there. On sterilized hard-maple blocks it grows vigorously, covering the blocks with a dense, thick mat.

The optimum temperature for growth (for an isolate from *Acer Negundo*) is given as about 25° C. The inhibiting temperature for growth is 35° C. (6). This places the fungus in the intermediate-temperature group of Humphrey and Siggers (13), i.e. with optimum growth between 24° C. and 32° C. The fungus is actually on the lower temperature border, however, and it may at times fall into the low-temperature group, i.e. that with optimum growth at 24° or below, since one degree is well within the limits of experimental error.

Porose areas were evident in cultures six weeks old. The fruit-

ing structure produced the capitate incrusted cystidia and globose spores characteristic of *Fomes connatus*.

The fungus exhibits a positive but not a strong reaction to tannic-acid medium, though occasionally the reaction is negative, according to Davidson, Campbell, and Blaisdell (9).

*Decay.* — *Fomes connatus* first causes the light-colored wood of maple to darken. The more advanced rot has a stringy appearance and is irregular in outline. This is one of the few heart-rotting fungi that decay the wood so completely that a hollow butt results.

The rot rarely spreads more than a few feet in either direction from the fruiting body, so that, as a rule, a cull extending three feet above the highest sporophore is sufficient. Sporophores usually form shortly after a small amount of decay has taken place, so that rotted trees can soon be detected. These should be discriminated against in stand-improvement work (2).

*Poria pereffusa* (Murr.) Sacc. and Trott., Syll. Fung.,  
21 : 335. 1912

(Plate IX, Fig. 1)

*Fomitiporia pereffusa* Murr., North Am. Fl., 9 : 10. 1907.

Type:

*Fomitiporia pereffusa* Murr. on oak log, Ohio Pyle, Pa. W. A. Murrill, Herb. New York Botanical Garden, New York.

Fructification perennial, for several years broadly effused, up to 15 mm., commonly 8–10 mm., thick, inseparable; sterile margin 0.5–1 mm. wide, slightly inflexed, “drab,” becoming blackish in age and finally disappearing, subiculum brown, often superimposed over a narrow black line, less than 0.3 mm. thick, and often scarcely distinguishable in old plants; tubes mostly distinctly, sometimes indistinctly, stratified, inconspicuously whitish-stuffed, “snuff-brown,” 2–3 mm. long; mouths glistening, circular to subcircular, 6–8 to a mm. “Saccardo’s umber,” “raw umber,” or “olive-brown,” in old specimens becoming “mouse-gray” in the marginal portions of the fructifications; dissepiments entire; basidia 5–6  $\mu$  in diameter, spores smooth, faintly brown, ellipsoid to globose, 4–4.5  $\times$  3–4  $\mu$ ; setae small, their points only

extending beyond the basidia,  $14-24 \times 3-6 \mu$ , myphae of the subiculum  $2-4 \mu$  in diameter.

*Allied species.* — *Poria pereffusa* may be confused with *Fomes igniarius* var. *laevigatus* (*P. laevigata* (Fr.) Cooke). The plants are to be separated largely upon a combination of characters that are, unfortunately, mostly relative. The spores of *P. pereffusa* are small,  $3.5-4.5 \times 2.5-3.5 \mu$  (Overh.).<sup>2</sup> The spores of *Fomes igniarius laevigatus* are hyaline. It is evident that faint spore colors may readily be mistaken for hyaline, but the spores of the two plants also differ in size. The smallness of the spores of *Poria pereffusa* is distinctive, and if the spores are pale rusty, one can be certain of the identification. Furthermore, the setae are rather numerous in specimens of *F. igniarius laevigata*, whereas in *P. pereffusa* they are not abundant. The tubes of *F. igniarius laevigata* are white-incrusted in the old layers, but inconspicuously whitish-stuffed in *P. pereffusa*. *F. nigricans laevigata* occurs chiefly on species of *Betula*, whereas *P. pereffusa* is most often found on species of *Quercus*.

*Fomitiporella floridana* Murr. suggests *Poria pereffusa*, but does not have any setae (cystidia), according to the description. The spore color (following Overholts' redescription of spore color for *P. pereffusa* and not the original account) is apparently similar.

*Habitat.* — *Quercus* sp.

*Distribution.* — Ohio, Pennsylvania; said by Murrill to range from Ontario to Alabama and west to Minnesota.

*Fomitiporella melleopora* Murr., North Am. Fl.,

Pt. I, p. 13. 1907

(Plate IX, Fig. 2, and Plate X)

Type and important specimens examined:

*Fomitiporella melleopora* on *Salix* sp., Feb. 11, 1886. A. B. Langlois 213. Type. Herb. New York Botanical Garden, New York.

*Fomitiporella melleopora* on *Populus tremuloides*, June, 1926, Devil's Lake, Wisconsin. Herb. Dow V. Baxter, Ann Arbor.

*Fomitiporella melleopora* on *Populus balsamifera*, Atlanta, Michigan. Herb. Dow V. Baxter, Ann Arbor.

<sup>2</sup> Originally the spores were described as hyaline, but Overholts discovered that they were "pale rusty": "The type collection is mostly sterile but on one occasion when I examined it I found the spores as indicated."



*Fomitiporella melleopora* on *Populus tremuloides*, July 23, 1946, Au Sable River, Huron National Forest, Michigan. Coll. Gene Hesterberg and Dow V. Baxter. Herb. Dow V. Baxter, Ann Arbor.

Fructification perennial, appearing at first in several small, bright, glistening brown patches about 3 mm. in diameter, becoming confluent and finally effused for as much as 1 meter, but usually much less, up to 12 mm. thick, mostly about 5 mm. thick, checking upon drying; margin undulate, slightly elevated, finely tomentose, 0.3 mm. wide, at first bright "raw sienna" becoming "wood-brown" or "Natal brown" in old specimens; subiculum up to 1 mm. thick, "yellow ocher" to "buckthorn-brown"; tubes becoming rather distinctly stratified, 1-7 mm. long each season, fulvous within; mouths circular, nearly regular, 5-6 to a mm., flavous to melleous when young, "yellow ocher" becoming umbrous with age, "bister," edges thick, entire; spores globose, thin-walled, smooth, pale ferruginous, but more hyaline than brown,  $3-4 \times 3-4 \mu$ ; hyphae ferruginous; no setae.

*Allied species.* — *Fomitiporella melleopora* is readily confused in the young state with *Poria pereffusa* (Murr.) Sacc. and Trott, not only because of the glistening, similar colors, but also because of the refracting nature of the mouths of the two plants. These two resupinate polypores are often misinterpreted. In addition, old plants of *F. melleopora* are so different in color and brightness (though they still glisten) from the young plants that it is possible to find immature specimens of *F. melleopora* under one name in herbaria and older plants under another. Furthermore, herbarium collections rarely represent all the stages, from young plants to stratified ones.

Although *Poria pereffusa* and *Fomitiporella melleopora* are macroscopically similar in color and although both glisten in the light when young, older specimens of *P. pereffusa* seem somewhat more woody than mature collections of *F. melleopora*, the latter suggesting a more fragile or brittle pore surface, even though it is definitely firm. The mouths of the tubes are slightly larger in stratified specimens of *F. melleopora* (mostly 5-6 to a mm.) than they are in *P. pereffusa* (mostly 6-8 to a mm.). The difference is plainly characteristic, but (as is true of many resupinate polypores) is not great enough to be of diagnostic value. There are no setae in *F. melleopora*, but setae occur in *P. pereffusa*,

though they are never abundant, often appearing in twos. The spores of both species are ellipsoid or subglobose and pale ferruginous, that is, more hyaline than brown. Murrill originally described *P. pereffusa* as having hyaline spores, in contrast to the pale ferruginous spores of *F. melleopora*. I could not find spores in the type, but Overholts reports that it is mostly sterile. On one occasion he found pale rusty spores, but on another was unable to find any spores. The small spores of *P. pereffusa* (the spores are only slightly larger in *F. melleopora*) and the setae are distinctive characters. *P. pereffusa* is most common on oak, whereas *F. melleopora* grows chiefly on species of the genera *Salix* and *Populus*.

*Habitat.* — *Populus balsamifera*, *P. tremuloides*, *Salix* sp. (?)

*Distribution.* — Louisiana, Michigan, Wisconsin.

*Occurrence.* — This plant is thought to be a common one, even though the records do not indicate the fact. It is believed that the inadequate records of its distribution are largely due to the plant's being so readily confused with others of the brown porias, ordinarily classified under this genus and under the genus *Fomitiporia*.

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**PLATES I-X**



*Poria herbicola* sp. nov., on lawn, Ann Arbor, Michigan





*Poria Diospyri* sp. nov., on *Diospyrus virginiana*, Sand Springs, Oklahoma

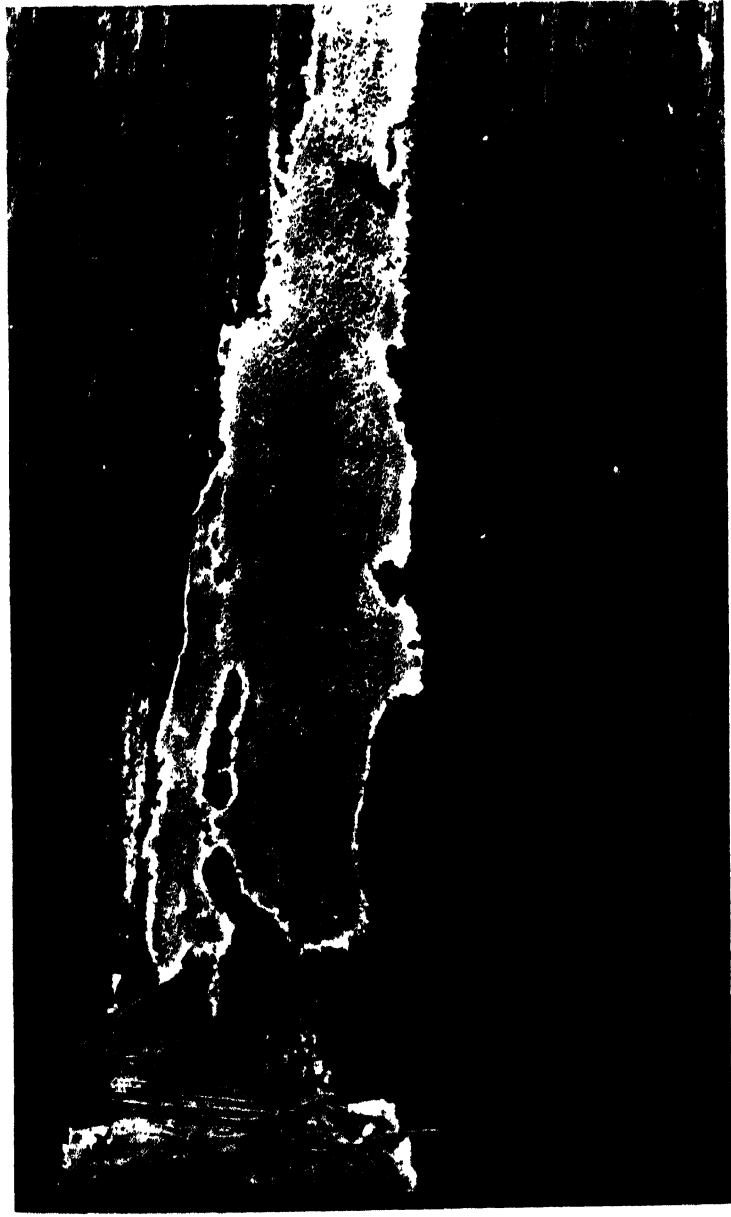






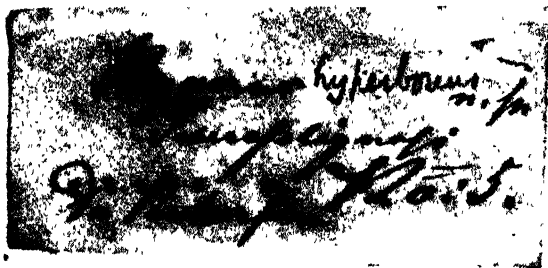
*Fomes robustus Tarodni* var. nov., on *Tarodum distichum*. Okefenokee Swamp, Georgia





Resupinate *Polystictus abietinus* on white-spruce planking on flume at sawmill near Summerside, Province of Prince Edward Island, Canada





Resupinate form of Polystictus  
pargamensis B. S.  
 B. S.

*Polyporus hyperboreus* Berk., Cooke, *Grevillea*, 15: 27. 1886. Royal Gardens, Kew, England. This is evidently a resupinate specimen of a *Polyporus* (*Coriolus*) species as indicated by Cooke, probably *Polystictus* (*Polyporus*) *pargamensis*, as noted on the herbarium sheet

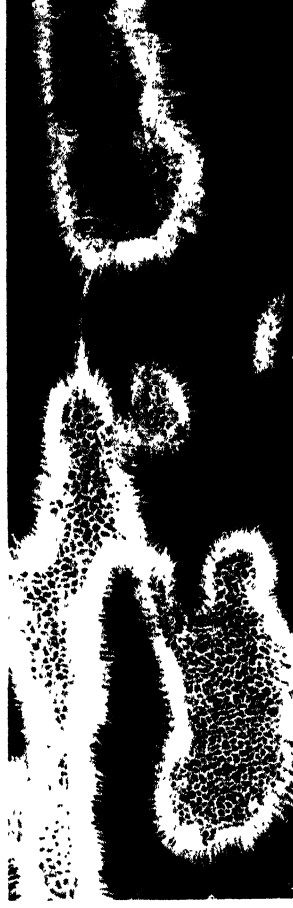
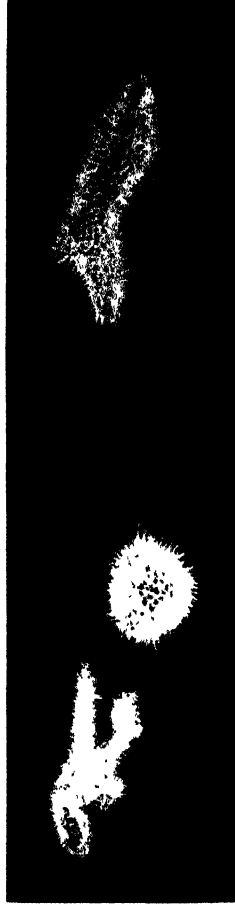




*Polyporus abietinus theleporoides* var. nov. Lake Quinault, Washington







*Poria bombycina* (Fr.) Cooke, from a von Post painting directed and approved by E. Fries.  
Margin "pinkish buff" to "avellaneous"; mouths "cinnamon-buff." Riksmuséet,  
Stockholm, Sweden





Resupinate fruiting bodies of *Fomes connatus* on trunk of *Acer saccharum* in cankered area, Amasa, Michigan



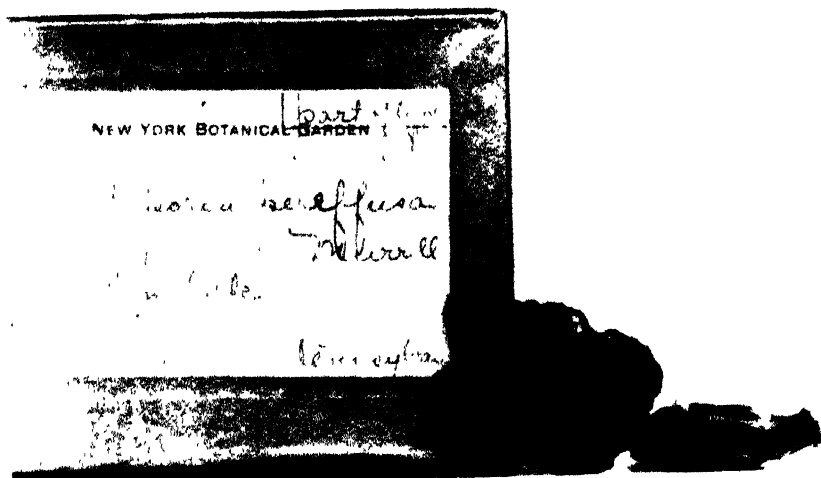


FIG. 1. *Fomitiporia pereffusa* (*Poria pereffusa* (Murr.) Sacc. & Trott.). Type. Herb. New York Botanical Garden



FIG. 2. *Fomitiporella melleopora*. Type. Collected near New Orleans, Louisiana, on willow log, Feb. 11, 1886, A. B. Langlois 213. Herb. New York Botanical Garden





*Fomitiporella melleopora* on *Populus tremuloides*, Au Sable River, Michigan National Forest, Michigan. Note the contrast between the old mature form and the patchy growth of young plants. The young plants are "raw sienna" and become "wood brown" or "Natal brown" in old-growth stages and much less glistening





# PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

EDITORS

EUGENE S. McCARTNEY

FREDERICK K. SPARROW

VOLUME XXXIII (1947)

PART I: BOTANY AND FORESTRY

"Pusilla res mundus est nisi in illo  
quod quaerat omnis mundus habeat."

— SENECA, *Naturales Quaestiones*

ANN ARBOR: THE UNIVERSITY OF MICHIGAN PRESS  
LONDON: GEOFFREY CUMBERLEGE, OXFORD UNIVERSITY PRESS

1949

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**Set up and printed,  
February, 1949**

**PRINTED IN THE UNITED STATES OF AMERICA  
BY E. L. HILDRETH AND CO. • BRATTLEBORO • VERMONT**

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# **BOTANY**



## STUDIES IN THE GENUS PORIA

### III. WHITE AND BRIGHTLY COLORED SPECIES \*

JOSIAH L. LOWE

THIS paper is a continuation of the writer's studies of type specimens or other authentic or interesting material of *Poria*. For this series type collections of sixteen species were studied, of which thirteen are reduced to certain or probable synonymy, and two are recognized as distinct; for one of these further distribution records are presented. The writer is indebted to the directors of the following herbaria for the privilege of studying specimens under their care: Kew Herbarium, Surrey, England; the New York Botanical Garden, New York City, New York; the Farlow Reference Library and Cryptogamic Herbarium, Cambridge, Massachusetts; and the Mycological Collections, Bureau of Plant Industry, Beltsville, Maryland.

*Poria alabamiae* (Berk. and Cooke) Cooke.—This species has been compared with *Poria unita* (Pers.) Karst. and its allies by a number of writers, and was placed in synonymy with *P. unita* by Overholts (4). The external appearance and all internal characters agree closely except that the spores of *P. alabamiae* are hyaline, smooth, oblong with rounded ends,  $8-13 \times 3.5-4.5 \mu$  (or  $10-12 \times 4-5 \mu$  by Bresadola's measurement, as indicated by annotations on the type sheet [at Kew]), whereas those of *P. unita* are oblong-ellipsoid to oval or subglobose,  $4-7 \times 2.5-5 \mu$ . The spore shape of *P. alabamiae* is wholly different from that of species in the *Poria unita* complex, and the species is probably not closely related to any member of that complex. A complete description of *P. alabamiae* is supplied:

Annual, probably rather widely effused. Margin nearly white, up to

\* Contribution from the Department of Forest Botany and Pathology, The New York State College of Forestry, Syracuse, New York.

The first of the studies was published in these *Papers*, 32: 99-101. 1948; the second, in *Lloydia*, 10: 45-59. 1947.

1 mm. wide, soft-fibrous or in part glazed. Pore surface light buff, the tubes soft, waxy-corky, up to 1 mm. long, the mouths rounded, averaging 4 per mm., the edge rather narrow, entire. Subiculum light buff, up to 0.5 mm. thick, soft spongy-fibrous. Sections not changing color in KOH, the subiculum hyphae closely interwoven, difficultly separable by pressure, 2–2.5  $\mu$  in diameter, nonseptate, the walls thick to solid; trama continuous with the subiculum and of similar hyphae. Cystidia none; basidia 11  $\mu$  in diameter; spores (not seen attached to basidia) hyaline, smooth, oblong with rounded ends, 8–13  $\times$  3.5–4.5  $\mu$  (or 10–12  $\times$  4–5  $\mu$  by Bresadola's measurements).

Known only from the type collection, Gainesville, Florida, Ravenel 102. Collections subsequently reported under this name have not been examined.

*Poria albo-lutea* Bourd. and Galz.—Material agreeing with published descriptions was collected in 1945 for the first time in North America, at Chapel Hill, North Carolina (Lowe 2867, 2910, 2936).

*Poria aurantiaca* var. *saloisensis* (Karst.) Sacc.—This variety was described from a collection in Finland and later referred to synonymy with *Poria nitida* (Pers.) Cooke by Bresadola (2, p. 77), and to synonymy with *P. aurantiaca* (Rostk.) Sacc. by Bourdot and Galzin (1) and Pilát (6). Authentic specimens of these two species have not been available for examination, but it has been established that the variety recognized by Karsten is the same as the fungus recently described by Overholts and Lowe (5) as *Poria rubens*. A specimen collected in Finland by Karsten and now in the New York Botanical Garden agrees in all respects with type material of *P. rubens*, as does a specimen in the Farlow Herbarium from the Tirol, determined as "*P. placenta*" by Litschauer.

*Poria placenta* (Fries) Cooke and *P. aurantiaca* var. *saloisensis* have frequently been confused in the past, but can readily be separated. The first has spores 4.5–6  $\times$  1.5–2  $\mu$ , and the subiculum hyphae lack clamp connections, although the hyphae are septate. The latter has spores 3.5–5  $\times$  2–2.5  $\mu$ , and the hyphae have clamps. The only known North American collection of *P. placenta* is from Isle Royale, Michigan; E. T. and S. A. Harper 1016 (Farlow Herbarium; and Mycological Collections, Bureau of Plant Industry).

*Poria argillacea* Cooke was based on two collections (now at Kew) from California, one of which, on wood of *Pinus lambertiana* Dougl.,



seems to be the same as *P. aurantiaca* var. *saloisensis*. It is sterile, however, and certain determination cannot be made. The other collection, on oak, is also sterile and is in such poor condition that its identity probably cannot be determined.

*Poria beaumontii* Berk. and Curt.—The type material (at Kew) is sterile and its identity is uncertain. Otherwise it agrees well with *Poria tenuis* (Schw.) Cooke.

*Poria cincinnati* Berk.—Although sterile, the type material (at Kew) agrees perfectly in all other characteristics with *Polyporus tulipiferus* (Schw.) Overh.

*Poria dryina* (Berk. and Cooke) Cooke.—The type material (at Kew) seems to be the same as *Poria cremor* (Berk. and Curt.) Cooke and *P. limitata* (Berk. and Curt.) Cooke, and hence is very doubtfully distinct from *Poria unita*. Final decision on all these species and on *P. holoxantha* Berk. and Cooke should be made by comparing the types with adequate material collected in the type localities by a competent collector.

*Poria fagicola* Bres.—The type collection (Weir 19070) does not appear to differ from type material of *Poria semitincta* (Peck) Cooke or *Poria fatiscens* (Berk. and Rav.) Cooke. The latter is the valid name for this fungus.

*Poria fuscomarginata* Berk.—The type material (at Kew) does not appear to differ from *Poria subacida* (Peck) Sacc.

*Poria holoseparans* Murr.—Although the type material which was studied is sterile it does not appear to differ from *Poria undata* (Pers.) Bres.

*Poria holoxantha* Berk. and Cooke.—The type material (at Kew) is the same as *Poria cremor*, *P. dryina*, and *P. limitata*, and thus is doubtfully distinct from *Poria unita*.

*Poria incrustans* (Berk. and Curt.) Cooke.—The identity of this plant is still uncertain, since the type collection is sterile. Exactly similar additional material from Virginia (Overholts Herbarium 4007, coll. A. S. Rhoads), and from Vermont (Farlow Herbarium, coll. E. A. Burt) has been examined. The Vermont collection, which is fertile, has spores that are hyaline, smooth, oblong-ellipsoid,  $4-5 \times 3-3.5 \mu$ .

*Poria millavensis* Bourd. and Galz.—The collection reported by Overholts (3) from Vermont does not appear to agree with the description of that species given by Bourdot and Galzin (1), since the spores

are not subglobose. Although the colors of the fresh plant are unknown and although this specimen shows no rhizomorphs, all other characteristics are those of *Poria subradiculosa* Murr.

*Poria omaema* Berk.—The type collection (at Kew) does not differ from *Poria subacida* (Peck) Sacc.

*Poria rhoadsii* Murr.—This does not appear to differ from type material of *Poria phlebiaeformis* Berk. deposited in the Farlow Herbarium. The latter seems to be a valid species and not a synonym of *Poria spissa* (Schw.) Cooke, as sometimes indicated.

*Poria similis* Bres.—This species, described from Idaho, also occurs in the eastern United States, and specimens have been examined from Pennsylvania (Overholts Herbarium 8652), Ohio (Morgan 133), Michigan (A. H. Smith 1152; C. H. Kauffman, three collections), and Missouri (Demetrius, New York State Museum Herbarium).

*Poria sulphurella* (Peck) Sacc.—A recent reëxamination of the type collection shows that this species does not differ from *Poria xantha* (Fries) Cooke.

*Poria tegillaris* Berk.—The type material (at Kew) is sterile and so poorly developed that it seems improbable that its identity can be determined. The species should be dropped from further consideration.

*Poria tomentocincta* Berk. and Rav.—The type material (at Kew) does not appear to differ from *Poria pulchella* (Schw.) Cooke.

THE NEW YORK STATE COLLEGE OF FORESTRY  
SYRACUSE, NEW YORK

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# FORESTRY



## SOME RESUPINATE POLYPORES FROM THE REGION OF THE GREAT LAKES. XIX \*

DOW V. BAXTER

**R**ESUPINATE polypores from the region of the Great Lakes occur generally throughout the North American continent. *Poria borbonica*, *Poria heteromorpha*, and a very few other species have not been collected in this area and are not likely to be.

Since the first paper of this series was published (1927)<sup>1</sup> field work has been conducted throughout the continent from the Arctic Ocean and Bering Sea areas in Alaska through the Yukon Territory and the Northwest Territories and all the Canadian provinces to the colony of Newfoundland. Numerous records of both distribution and substrata have been added since many of the accounts appeared.<sup>2</sup> Likewise, additional information has been obtained in the laboratory relative to the features of many of these fungi in culture.

Paper 19 presents the reactions of *Poria ferox* Long and Baxter (Paper 11 of this series), *Fomitiporella melleopora* (Paper 18 of this series), and *Fomes Earlei* in culture. Additional accounts of resupinate polypores are given, and two new species are described.

\* Throughout the work on these monographs I have been indebted to many individuals and institutions for suggestions, help, and privileges extended to me. My appreciation is expressed particularly to the men who have accompanied me on my ten expeditions to Alaska, the Yukon Territory, the Northwest Territories, Newfoundland, and Labrador. They aided me in the collection and care of specimens and at times lived under rather difficult circumstances. I am under obligation to Professor T. G. Halle, of Naturhistoriska Riksmuséet in Stockholm, with whom I have had the pleasure of association. Thanks are due several American institutions and scholars also. To the authorities at the New York Botanical Garden, to Dr. W. H. Long, Albuquerque, New Mexico, to the staff of the Division of Pathological and Mycological Collections of the United States Department of Agriculture, and to Professor H. H. Bartlett, of the University of Michigan, I am especially indebted.

<sup>1</sup> All these articles have appeared in the *Papers of the Michigan Academy*.

<sup>2</sup> Ultimately these early records will be revised so as to incorporate the new information obtained on the various expeditions, as well as in the laboratory, and will be published under the title "The Resupinate Polypores of North America."

The color terms given within quotation marks are those of R. Ridgway, *Color Standards and Color Nomenclature* (Washington, 1912).

*Poria quercuum* sp. nov.

(Plate I)

*Type specimen.*—*Poria quercuum* sp. nov. on *Quercus stellata*, Branson, Missouri, February 5, 1947. Dow V. Baxter. Herb. Dow V. Baxter, Ann Arbor.

Fructificatio albida, annua, per maculas irregulares usque ad 30 cm. effusa, siccitate fragilis separabilisque, coriacea, plerumque 2–3 mm. crassa; marginibus c. 1 mm. latis, juventate albis, tomentosis, aetate fertilibus, pallide ochraceis; subiculo albido, saepissime minus quam 0.3 mm., inconspicuo, in plantis vetustis saepe nullo; tubis 2–3 mm. longis, diametro plerumque 3 (vel raro 2) per spatium 1 mm., parietibus crassis, primum albidis demum similibus (in speciminibus herbariorum cito siccatis) vel plus minusve pallide ochraceis vel flavidis in speciminibus naturalibus siccis, aspectu cretaceis sed firmis; sporis laevibus, hyalinis, allantoideis, 3.5–4  $\mu$  longis, 1  $\mu$  latis; hyphis hyalinis, 2–4  $\mu$  (plerumque 3–4  $\mu$ ) diametientibus.

Fructification whitish, annual, effused in irregular patches for as much as 30 centimeters, cracking or checking and becoming somewhat separable upon drying, coriaceous, mostly 2–3 mm. thick; margin white at first, tomentose, approximately 1 mm. wide, becoming fertile with age and appearing “cream buff” or “chamois”; subiculum whitish, mostly less than 0.3 mm. and inconspicuous, often disappearing in old plants; tubes 2–3 mm. long, mostly 2.5–3 mm.; mouths 2–3 to a mm., mostly 3, edges thick, white at first and remaining whitish in herbarium material or turning to “chamois” or “honey yellow” upon drying, appearing somewhat chalky but not rubbing off, spores smooth, hyaline, allantoid, 3.5–4  $\times$  1  $\mu$ ; hyphae hyaline, 2–4, mostly 3–4  $\mu$ , in diameter.

*Allied species.*—Among the porias *Poria quercuum* might suggest macroscopically weathered and old specimens of *P. xantha crassa*. The spores are approximately the same in size. Although *P. xantha crassa* occurs chiefly on conifers, it has been collected on hardwoods. *P. quercuum* is known only on broad-leaved species. It is not so chalky in texture and does not rub off between the fingers, as does *P. xantha crassa*. The pores of *P. quercuum* are much larger, 2–3 to a mm., whereas those of *P. xantha crassa* average about 5 to a mm.

*Poria quercuum* bears some resemblance to *Trametes serialis* and *T. sepium* because of its coriaceous nature and size of tubes and pore mouths. The smaller spores of *P. quercuum*,  $3.5-4 \times 1 \mu$ , will distinguish it from these plants. Spores of *T. serialis* are  $7-9 \times 2-3 \mu$ , and those of *T. sepium* are  $8-14 \times 3.5 \mu$ . *T. Morgani* Lloyd, which is also in this group, is interpreted variously, but regardless of the name used all the plants in this complex have much larger spores than *P. quercuum*. Among them is *T. Trogii* Berk., which has spores that measure  $8-10 \times 2.5-3 \mu$ . This plant, as interpreted by Overholts, and *T. Morgani* are synonymous.

*Poria quercuum* may look like weathered specimens of *Poria unita* and may suggest this species macroscopically. Furthermore, oak is a common substratum for *P. unita*. These two polypores may readily be separated by spore measurements. The spores of *P. unita* are oblong-ellipsoid to oval or subglobose, whereas those of *P. quercuum* are allantoid,  $3.5-4 \times 1 \mu$ .

**Cultures.** — Isolated from *Quercus stellata* from Branson, Missouri. Young cultures of *Poria quercuum* are snow white and cottony in texture. Growth of this rapidly growing fungus is equally fast at  $25^{\circ}\text{C}$ . and  $30^{\circ}\text{C}$ . (filling the petri dish at these temperatures within 7 days). Furthermore, the rate of growth is only slightly reduced at  $35^{\circ}\text{C}$ . (approximately 19.4 mm. in 7 days and 39.5 mm. in 14 days).

*Poria quercuum* develops on both red-gum and white-pine blocks in culture.

**Habitat.** — *Quercus stellata* and probably other native oaks of the south-central United States and the Southwest.

**Distribution.** — Missouri, probably Arkansas, Oklahoma, and the southwestern sections of the United States.

**Decay.** — A white indeterminate rot with wefts of whitish mycelium appearing in the checks of the substratum.

*Poria crustulina xerophytica* var. nov.

(Plate II)

Type:

*Poria crustulina xerophytica* var. nov. on *Torreya californica*, July 25, 1938. Dow V. Baxter. Herb. Dow V. Baxter, Ann Arbor.

Fructificatio albida, annua vel raro perennis, longe effusa, longitudine usque ad 15 cm.; margine saepe conspicuo, 1-2 mm. lato, tomentoso, sterili, albide ochraceo, vel pallide salmonicolori plerumque siccitate

rubide ochraceo; tubis unistratosis, raro bistratosis, longitudine usque ad 3 mm., plerumque 2 mm., cum oribus concoloribus; oribus albidis vel pallide ochraceis vel ochraceis, siccitate plerumque pallide ochraceo-salmonicoloribus vel rufis, 0.3–0.5 mm. diam., plerumque 0.5 mm., dissepimentis crassis; basidiis 4-sporis; sporis 3–3.5  $\mu$  diam., 6.5–7  $\mu$  longis; hyphis hymenii 1–4  $\mu$ , plerumque 1–3, saepe incrustatis; cystidiis nullis. In truncis *Torreya californicae* prope silvas "Muir Woods" dictas, in vicinitate San Francisco, California, Jul. 5, 1938; legit Dow V. Baxter.

Fructification whitish, annual or rarely perennial, effused in patches up to 15 cm. long; margin often conspicuous, 1–2 mm. wide, tomentose, sterile, whitish "cartridge buff," pale "pinkish buff," drying mostly "pinkish buff"; tubes in one layer, rarely in two, up to 3 mm. long, mostly about 2, concolorous with the mouths; mouths whitish "light buff" to "capucine buff," drying chiefly to "light ochraceous salmon" to "tawny," 2–3 to a mm., mostly 2 to a mm., dissepiments thick; basidia 4-spored; spores 3–3.5  $\times$  6.5–7  $\mu$ ; hyphae of the trama 1–4  $\mu$ , mostly 1–3, often incrustated; no cystidia. On *Torreya californica*, vicinity of Muir Woods, near San Francisco, California, July 5, 1938.

*Allied species.* — *Poria crustulina xerophytica* is intermediate in macroscopic appearance between *P. crustulina* and *P. subfusco-flavida*, but microscopically it is related more closely to *P. crustulina*. It may be distinguished from *P. subfusco-flavida* by the larger mouths and the somewhat larger spores. Its spores are described as being 3–3.5  $\times$  6.5–7  $\mu$ , whereas those of *P. subfusco-flavida* are narrower, being (1.5) 2–2.5  $\times$  4.5–7  $\mu$ .

The more distinctly allantoid spores of *Poria crustulina* and their slightly smaller width will serve to distinguish the species from variety *P. crustulina xerophytica*. Spores of *P. crustulina* are 2–3  $\times$  5.5–7 (8)  $\mu$ . *P. crustulina* is usually a thicker plant that covers wide surfaces of the substratum much as does *P. subacida* and checks or cracks upon drying. *P. crustulina xerophytica*, being thinner, does not crack open upon drying. It is more faintly pinkish, "light ochraceous salmon," and less "cinnamon buff" than the species *P. crustulina*. Both plants are on coniferous wood; *P. crustulina* attacks species of Pinaceae, whereas *P. crustulina xerophytica* is known only on the California nutmeg in the Taxaceae, namely, *Torreya californica*.



*Poria Cocos* (Schw.) Wolf, Journ. Elisha  
Mitch. Sci. Soc., 38 : 127-137. 1922

(Plates III-IV)

*Lycoperdon solidum* Clayton, Fl. Virg., p. 176. 1762.<sup>3</sup>

*Lycoperdon cervinum* Walt., Fl. Carol., p. 262. 1788.

*Sclerotium giganteum* MacBride, Trans. N. Y. Philosoph. Soc. 1817.

*Sclerotium Cocos* Schw., Syn. Fung. Carol. Super., pp. 30-31. 1822.

*Pachyma Cocos* (Schw.) Fries, Syst. Myc., 2 : 242-243. 1823.

*Pachyma solidum* Oken, Lehrbuch d. Naturg., 2ter Teil, Botanik. 1925.

*Lentinus Tuber regium* Fries, Epic. Syst. Myc., p. 392. 1836.

*Pachyma pinetorum* Horaninow, pp. 2-23. 1856.

*Pachyma coniferarum* Horaninow. 1856.

*Tuckhaus rugosus* Rafinesque, Med. Fl. N. Am., 2 : 255. 1830.

Type and important specimens examined:

*Poria Cocos* on corn and pine. Coll. F. A. Wolf, det. F. A. Wolf. U. S. Dept.  
Agric. Pathological and Mycological Collections, Beltsville, Md.

**Fructification**<sup>4</sup> appearing on a sclerotium; the sclerotia varying considerably in size and shape, frequently resembling a potato, but often much longer and larger, sometimes weighing as much as 10,000 grams (22½ lb.), easily cut with a knife when fresh, but drying extremely hard; interior becoming cracked, but the fissuring not perceptible from the exterior, cortex roughened and having the color of pine roots, the appearance suggested best in specimens in which flakes of bark constitute a part of the sclerotial context, the cortex consisting of densely compacted fungus cells making a well-defined layer 100-150  $\mu$  in thickness, interior whitish or tinged with pink when fresh, drying gray; fructification white and cartilaginous at first, becoming slightly brown and papery upon drying; margin fertile; tubes 2-3 mm. long; mouths large, angular, sinuous; basidia blunt, 20-30  $\times$  6-8  $\mu$ , 4-spored; spores cylindric, smooth, 7-8  $\times$  3.5  $\mu$ . Obovate conidiospores, 3-4  $\times$  5-6  $\mu$ , have been reported on the surface of a sclerotium (4).

**Conditions for fructification.**—Fructification upon the sclerotium is apparently conditional upon at least three factors: (a) fresh sclerotia; (b) saturation with water, and (c) the presence of light (32). If the sclerotium has not dried out, the fungus can be made to fruit within a few days by placing in a moist chamber parts of the sclerotium which have been soaked in water.

<sup>3</sup> The list of synonyms has been reported by Weber (30).

<sup>4</sup> The description presented here is based largely upon that of Wolf (32, 33).

**Habitat.** — *Abies balsamea*, *Betula lutea*, *Citrus paradisi*,<sup>5</sup> *C. sinensis*,<sup>5</sup> *Carya sp.*,<sup>6</sup> *Erythrina herbacea*, *Eucalyptus sp.*,<sup>5</sup> *Fagus grandifolia*, *Juniperus virginiana*, *Magnolia grandiflora*,<sup>5</sup> *Pinus caribaea*, *P. echinata*, *P. rigida*,<sup>7</sup> *P. taeda*,<sup>7</sup> *Prunus serotina*, *Quercus alba*,<sup>8</sup> *Q. borealis maxima*,<sup>8</sup> *Q. coccinea*,<sup>8</sup> *Q. montana*,<sup>8</sup> *Q. phellos*,<sup>5</sup> *Q. velutina*,<sup>8</sup> *Rhus sp.*, *Taxodium distichum*, *Tsuga canadensis*, *Zea Mays*.

**Distribution.** — Manitoba, Saskatchewan, Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Kansas, Kentucky, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey, New York, North Carolina, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Wisconsin.

**Occurrence.** — The tuckahoes occur largely in sandy soil and may be slightly covered with sand or actually buried several feet deep, according to Weber (30).

Gore (14) also reports them as occurring in light sandy soil or sandy loam that is not too wet, and they likewise occur in old fields or woodlands. Güssow (15) found the Canadian tuckahoe in poplar woods. They occurred eighteen inches deep in yellow ferruginous sand encircling an oak-tree root, according to Lockwood (22). Wolf (32) believes that the tuckahoes are generally attached to tree roots growing in sandy soils, in flat woods, hammock and grove lands of North Carolina. They are buried in sand in depths down to two feet (30). The occurrence of sclerotia on "little-leaf" diseased trees (*Pinus echinata*) has been recorded by Jackson (19). He frequently found sclerotia on little-leaf trees but not on healthy pine.

**Common names.** — Weber (30) has given so excellent a history of the common names applied to *Poria Cocos* (Schw.) Wolf that the material presented here is based largely upon his account. The earliest records concerning tuckahoes, according to this author, appeared in 1722 in a history of the State of Virginia, in which there are accounts relating to the tuckahoes that the Indians dug out of the ground. An earlier reference to tuckahoes, however, was located in a rare copy of a 1705 edition of the history and present state of Virginia which is in the William L. Clements Library of the University of Michigan (see Plate IV). The term "tuckahoe" is a common one for a certain type of sclerotium. It has also been used to describe various kinds

<sup>5</sup> Reported in Weber (30).

<sup>6</sup> Reported by Murrill (25).

<sup>7</sup> Reported by Wolf (32).

<sup>8</sup> Reported by Davidson, Campbell, and Vaughn (10).

of tuberous roots, as is indicated in this early reference, and Indians had similar terms to designate the tuberous roots collectively. "Tuck-ahoe," "tawkee," "ptucaui," "petukqui," and "pittikmow" were in common use (14, 30). Weber (30) reports that Peter Kahm, in his *Travels in North America*, published in 1772, listed the words "tawko," "tawking," "tuckah," "tawkee," "tawkin," "tockim," and "tockin" as names of more or less bulbous edible roots. It appears that the names mentioned include all tuber-like plants, whether they were of phanerogamic or cryptogamic origin. The present account has to do only with the fungus sclerotium designated by the binomial *Pachyma Cocos* (Schw.) Fries, by which the plant was known for almost a hundred years, or *Poria Cocos* (Schw.) Wolf, the name now correctly applied to it.

*Cultures*.—Isolated from oak by Davidson, Campbell, and Vaughn (10), and from *Pinus echinata* by Jackson (19). The reports here are based upon their data and upon the cultures in the Laboratory of Pathology in Forest Practice obtained from the United States Division of Forest Pathology.

The growth is usually rapid, forming either a "cartridge-buff" or a "pale pinkish-buff" mat, oppressed-cottony at center to loose-cottony at margins; or oppressed, "army brown" to "Vandyke brown," margins often loose-cottony; when first isolated inclined to be oppressed, brown, but becoming loose-cottony. Lacerate-poroid, white resupinate fruiting surfaces forming in ten-day-old mats. According to Jackson (19), isolates from short-leaf pine show minor variations from those isolated from oak by Davidson and others. These characters, the formation of chlamydospore-like cells, the fragrance of mycelium on cooked wheat, and the dark-brown form of growth are regarded as differences in isolates.

The submerged and superficial hyphae are 2–15  $\mu$  in diameter, thin-walled, prominent septations, often constricted and without clamp connections, breaking up into short irregular lengths with interspersed empty cells; irregular inflated cells either single or in chains; basidiospores cylindric, 7–9  $\times$  3–4  $\mu$ , viable.

Optimum temperature for growth is approximately 30° C. The most noticeable features of the fungus in culture, according to these investigators, are its fragile "pale pinkish-buff" mat; the exceptionally large septate, often much-constricted, hyphae; and the large connected, inflated cells. When the fungus fruits, the cylindric

basidiospores produced in coarse poroid or lacerate fruiting bodies are also distinctive.

The fungus gives a negative reaction to tannic-acid medium (9). *Pathogenicity*. — *Poria Cocos* has been inoculated on the roots of short-leaf pine two and three years old and grown in pots of nonsterile soil by Jackson (19). The roots of the seedlings were so treated at the time of transplanting by scattering grains of cooked-wheat inoculum through the soil about one-half inch from the roots. Controls were inoculated with sterile cooked wheat.

All the isolates of *Poria Cocos* spread rapidly in the soil, and in some pots poroid mats formed on the surface of the soil in fourteen days. Heavy losses of pine trees were caused in a relatively short time. "For all isolates the number of plants killed in twelve to ninety days varied from 79 to 100 per cent per series."

Feeding roots of the affected pine trees were decayed. Bark on the inoculated trees became loose and dark brown. The stele was light brown. *Poria Cocos* was reisolated from the steles.

The pathogenicity of the fungus as demonstrated (19) confirms Wolf's assumption (32) that the fungus is probably parasitic. The addition of woods humus to the soil at the time of inoculation failed to affect the pathogenicity of the poria.

*Economic importance and decay*. — From the report of Banning (1) and the accounts studied by Weber (30), it appears that the sclerotia were at times used as food, being roasted and eaten by natives or, later, by Negroes who had learned from the Indians that they were edible. They were also employed in making a kind of bread. Some records indicate that they were not eaten raw because they were poisonous. Fries (12) reported that they contained certain medicinal properties and were used by the natives in remedies. Rafinesque (27) believed that tuckahoes were the most delicate of all food, being odorless and having a fine taste. On the other hand, Murrill (24) did not think that they were a common source of food or that the sclerotia had any curative properties.

*Poria Cocos* has been isolated from decayed black cherry trees by Davidson and Campbell (8). These authors obtained cultures of the fungus six times from butt sections of *Prunus serotina*. The fungus is also reported as a cause of heartrot in oak. It might be assumed further that the fungus causes decay as a saprophyte, since it has been reported on railroad ties in service (4).

Sclerotia have invariably been found among the roots of pine trees, *Pinus taeda* and *P. rigida*, by Wolf (32), but the exact relationship of the fungus to these trees has not yet been determined.

*Polyporus balsameus* Peck, Ann. Rep. New York State Mus.,  
30:46. 1878

(Plate V)

*Polyporus apalus* Lév. (teste Pilát), Ann. Sci. Nat., p. 124. 1843

*Polyporus crispellus* Pk., Ann. Rep. New York State Mus., 38:91. 1885.

*Coriolus balsameus* (Pk.) Murr., N. Am. Fl., Pt. I, p. 21. 1907

*Coriolus kymatodes* (Rostk.) B & G (teste Pilát), Bull. Soc. Myc. de France,  
41:143. 1925.

*Coriolus apalus* (Lév.) B & G (teste Pilát), H. de Fr., 566. 1928

*Tyromyces crispellus* (Pk.) Murr., N. Am. Fl., 9:34. 1907

*Tyromyces balsameus* (Pk.) Murr., Myc., 12:7. 1920

*Tyromyces kymatodes* (Rostk.) Donk (teste Pilát), Med. Bot. Mus. Utrecht, 9:153.  
1933

*Leptoporus almaatensis* Pilát (teste Pilát), Bull. Soc. Myc. de France, 52:307, t. 3,  
f. 1-2. 1936.

*Leptoporus kymatodes* (Rostk.) Pilát, Atlas des Champignons de l'Europe, III. 214  
1936.

Fructification sessile, effused-reflexed, resupinate, or appearing substipitate, corky when fresh, rather rigid in dried specimens, 1-3 × 2-5 × 0.2-0.5 cm. (Lowe), surface whitish to pale brown, drying "light buff," markedly villose to tomentose, with lighter concentric zones, occasionally becoming reddish ("benzo brown") when bruised; margin thin; context white, 1-4 mm. thick; tubes white, 1-3.5 mm. long; mouths white, 2-6, mostly 4-5, to a mm.; edges thin, dentate; spores hyaline, smooth, frequently one-guttulate, ellipsoid to ovoid, 3-5 × 2-3 μ; hyphae seldom branched, 5-9 μ in diameter; cystidia thin-walled, not incrusting, 4-9 μ in diameter and projecting up to 20 μ.

*Allied species.*—*Polyporus floriformis* Quél. and *Pol. tephroleucus* Fr. have been reported as synonyms by Hubert (16), but are not so regarded in the present study. Cystidia are not present in *Pol. floriformis*. The spores of *Pol. tephroleucus* are allantoid, 4-5 × 0.7-1.5 μ (Overh.), in contrast to the ovoid spores of *Pol. balsameus*, which measure 3-5 × 2-3 μ.

*Habitat.*—*Abies balsamea*, *Betula lutea*, *Picea glauca*, *P. rubra*, *P. sitchensis*, *Pinus strobus*, *Prunus serotina*, *Thuja occidentalis*, *T. plicata*, *Tsuga canadensis*.

**Distribution.**—British Columbia, Nova Scotia, New Brunswick, Ontario; Newfoundland; California, Maine, Michigan, Minnesota, New Hampshire, New York, Oregon, Pennsylvania, Tennessee, Washington, Wisconsin.

**Occurrence.**—Although the fungus appears in the West Coast states, it is found chiefly from Minnesota eastward, through eastern Canada, and in New England. I have never discovered it on any of the western species of *Abies*. *Polyporus balsameus* is usually associated with decay in balsam fir and other conifers, but has been collected on yellow birch and black cherry on the Allegheny National Forest (8).

**Decay.**—*Polyporus balsameus* produces a brown cubical rot similar to that caused by *Pol. Schweinitzii*. In the early stages of decay infected areas become buff or buff yellow. Later the wood darkens to a clay color or a chocolate brown. Shrinkage cracks appear, and the attached wood breaks up into large cubes (3). A thin powder-like layer of mycelium often forms within the shrinkage cracks.

**Signs of rot.**—The fruiting bodies are in evidence for only a short period, and they usually occur on trees growing on moist sites. They may be found on the trunk at the base of limbs, but they are more commonly attached to exposed roots in the root crotches and basal scars. In nature insects soon destroy the fruiting bodies. Basal scars, fire scars, and frost cracks are usually observed in connection with trees showing this rot. Resin flow in the root crotches and along the exposed parts of roots often accompanies decay (16, 17)

**Cultures.**—Isolated from heartwood of *Abies balsameus* and sporophore tissues by Clara W. Fritz. Initial growth consists of delicate colorless hyphae, which bear numerous clamp connections. Within a week chlamydospores with thick, smooth hyaline walls form in terminal or intercalary positions and, according to Fritz (13), they produce conidium-like sprays in the first type and long beadlike chains in the latter. These chlamydospores measure  $7-10 \times 12-22 \mu$ . The fungus mats are at first thin, downy-hairy, with a broad, straggling, colorless appressed margin, becoming close-woolly and finally assuming a spongy texture over the surface. The fungus is white and gradually changes to "cream buff" and "cinnamon buff" to even drab in culture. *Polyporus balsameus* gives a negative reaction to tannic-acid medium.

**Importance.**—Butt rot in balsam due to *Polyporus balsameus* is secondary in importance to *Poria subacida*, but it contributes greatly

to the rapid deterioration of balsam-fir stands killed by *Harmolaga fumiferana* Clem., the spruce budworm (5).

Kaufert (20) reports that of 690 trees examined in the Lake States 70 per cent had butt rot alone and that 23 per cent had both butt and top rot. These studies were made in Minnesota and Wisconsin, and included sample areas on the Chippewa and Chequamegon national forests and on lands of the Northwest Paper Company and of the Minnesota and Ontario Paper Company. It might appear that the greatest amount of cull losses was caused by butt rot. Analysis of the data showed, however, that decay in all the trees amounted to 16.5 per cent of growth. Since the net increment is still appreciable on trees ninety years old, stands of that volume could probably be left. Of this volume 8.7 per cent was due to butt rot and 7.8 per cent to top rot. Although butt rot appeared in a far greater number of trees than top rot, apparently it did not cause as much cull. This result is due partly to the fact that butt rot is confined to the lower part of the bole, whereas top rot usually occupies a high percentage of the upper and merchantable part of the trunk.

Of the 642 trees with butt rot 471, or 73.4 per cent, had yellow stringy rot (caused by *Poria subacida*) and 110, or 17.1 per cent, had brown cubical rot. When estimates are made on a volume basis, *Polyporus balsamcus* caused 5.7 per cent of the losses, and *Poria subacida* caused 89 per cent. Hubert (16) states that in Door County, Wisconsin, most of the balsam firs ranging in diameter from three to eighteen inches were found to be infected with *Pol. balsamcus*. In badly rotted trees the rot column extended from six to twelve feet up in the trunk. Wind and snow breakage is common in many areas where the balsam are badly decayed.

Butt rot examined by Kaufert in balsam fir up to 60 years of age was of minor importance. In trees 60 to 150 years old it gradually increased until at 150 years it covered 41 per cent of the total volume of the tree. Considering the percentage of trees infected with butt rot, the percentage of decay, and the percentage of cull for the various age classes, it was determined that the net periodic increment in the tree is greatest at about 70 years, after which it decreases gradually until at approximately 100 years decay and cull offset age without severe decay losses. Kaufert reports, however,

that after 80 years damage from wind breakage would be considerable.

Balsam fir usually grows in uneven-aged stands in mixtures with other species, so that diameter relationships to decay incidence are of importance. Age determinations are costly to make in such forests. Kaufert finds that the percentages of rot and the percentages of cull increase with increase in diameter. The highest periodic increment is reached, however, at a diameter between 9 and 10 inches. The age of 9- or 10-inch balsam examined is about 90 years.

*Polyporus balsameus* in the interior of British Columbia was reported by Buckland (6) as being responsible for but little of the brown cubical rot that occurs in western red cedar. He points out, however, that some of the butt-decay infections attributed to other fungi may have been due to *Pol. balsameus* and adds that additional study may indicate a greater relative importance of the fungus as a cause for brown cubical rot in this tree.

*Poria aurea* Peck, 43d Rep. New York State Mus., p. 21. 1890

Type and important specimens examined:

*Poria aurea* on *Acer saccharinum* (other specimens on same sheet as type on conifers), Sevey, New York Herb. New York State Museum, Albany, New York

*Poria aurea* Pk., Coll. G. F. Atkinson, Port Jefferson, Long Island, New York 1904. Identification confirmed by Dr. Chas. Peck. Herb. G. F. Atkinson, Ithaca, New York

Fructification annual, effused up to separable when fresh (Peck), watery as in *Poria subacida* when fresh; margin byssoid, greenish yellow (Peck) in fresh growing plants; subiculum thin, "subgelatinous," drying somewhat translucent, inconspicuous; tubes 2-5 mm. long, concolorous with the mouths; mouths golden yellow when fresh, 2.5-5 to a mm.; spores oblong or short-cylindric, smooth, hyaline,  $5.5-7.5 \times 2.5-3.5 \mu$  (Overh.); cystidia abundant, conspicuous,  $30-50 \times 12-20 \mu$  (Overh.); hyphae branched, thin-walled, 2-3  $\mu$  in diameter, clamp connections present.

*Allied species.*—*Poria aurea* is most closely allied to *P. subacida* and may readily be confused with that species in the field, particularly in the West. The present appearance of the Peck specimen is much like that of a thin, watery *P. subacida*. Overholts (26) observed this and reported that it differs from *P. subacida*, "as it does from all other known species, in the well-developed, mainly unincrusted cystidia."



Colors, as well as the presence of unincrusted cystidia, are confusing, however, in the description of *Poria colorea* Overholts and Englerth as presented by Englerth (11). He stated that the sporophores of the yellow rot fungus "resemble those of *P. subacida* closely," but that "the sporophores of *P. subacida* are white when fresh, turning buff when old, while those of *P. colorea* are antimony yellow to golden yellow in color." Nonincrusted cystidia are listed in the description as " $16-20 \times 5-7 \mu$ " and as "seen occasionally." "The fungus should be referred to as *Poria colorea* Overholts and Englerth." In the description of *P. aurea* the pore surface is golden yellow, *vide* Peck.

Since the points of difference of *Poria colorea* and *P. subacida* do not seem significant, in this series *P. colorea* is not recognized as a species. The spore measurements of *P. colorea* are given for the Overholts and Englerth plant as broadly ellipsoid,  $4-5-6 \mu \times 3.5-4 \mu$ , whereas Overholts gives the spores of *P. aurea* as oblong or short-cylindric,  $5.5-7 \times 2.5-3.5 \mu$ .

*Habitat.*—*Acer saccharinum*, *Picea sitchensis*, *Tsuga heterophylla*.

*Distribution.*—Alaska, Oregon, New York.

*Polyporus adustus* (Willd.) Fr., Syst. Myc., 1:363. 1821

(Plate VI)

*Leptoporus adustus* (Willd.) ex Fr., Quél., Ench. Fung., 177. 1886

*Boletus adustus* Willd., Fl. Berol. Prod., p. 392. 1787.

*Boletus fuscoporus* Planer., Ind. Pl. Erf., p. 26. 1788

*Boletus suberosus flabelliformis* Batsch., Elench. Fung. Contin., 2: 117, pl. 226. 1789.

*Boletus carpineus* Sow., Eur. Fl., 2. t. 231. 1799

*Polyporus carpineus* (Sow.) Secretan (teste Pilát), Mycographie suisse, 3: 123. 1833

*Polyporus crispus* (Pers.) Fr., Syst. Myc., 1: 363. 1821

*Polyporus pallescens* Fr., Syst. Myc., 1: 369. 1821.

*Boletus isabellinus* Schw., Schr. Nat. Ges. Leipzig, 1: 96. 1822

*Polyporus subcinereus* Berk., Ann. Mag. Nat. Hist., II, 3: 391. 1839

*Polyporus demissus* Berk. (teste Pilát), Hook. Journ. Bot., 4: 52. 1845

*Polyporus Halesiae* Berk. & Curt., Ann. Mag. Nat. Hist., II, 12: 434. 1853

*Polyporus adustus carpineus* (Sow.) Fr., Hymen. Europ., 550. 1874

*Polyporus caeruleus* Fr. (teste Pilát), Hymen. Europ., 549. 1874

*Polyporus tristis* Fr. (teste Pilát), Hymen. Europ., 581. 1874

*Polyporus dissitus* Berk. & Br. (teste Pilát), Journ. Linn. Soc., 14: 48. 1875

*Polyporus Lindheimeri* Berk. & Curt., Grevillea, 1: 50. 1892.

*Bjerkandera adusta* (Willd.) Karst., Meddel. Soc. Faun. Fl. Fenn., 5: 38. 1879. In part.

*Polyporus Mac-Owani*, Kalch. (teste Pilát), Grevillea, 10: 54. 1880.

*Polyporus simulans* Karst. ex Lloyd, Synopsis of the Section Apus of the Genus *Polyporus*, p. 386. 1915.

- Myriadoporus adustus* (Willd.) Peck, Bull. Torr. Bot. Club, 11: 27. 1884.  
*Polystictus similans* (Berk. & Curt.) Sacc. (teste Pilát), Syll. Fung., 6: 117. 1888.  
*Polyporus Burtii* Peck, Bull. Torr. Bot. Club, 24: 146. 1897.  
*Coriolus alabamensis* Murr., N. Am. Fl., 9: 19. 1907.  
*Polystictus adustus* (Willd.) Big. & Guill. (teste Pilát), 2: 371, t. 27, f. 3. 1913.  
*Polystictus adustus* var. *crispus* (Pers.) Big. & Guill. (teste Pilát), 2: 372. 1913.  
*Polystictus carpineus* (Sow.) Konrad, Bull. Soc. Myc. Fr., 39: 14. 1923.  
*Gloeoporus adustus* (Willd.) Pilát, Atlas des Champignons de l'Europe, 157. 1936.

Fructification sessile, effused, reflexed-imbricate, often confluent, 1–5  $\times$  2–9  $\times$  0.1–0.8 cm., or often resupinate and occasionally extending over a long surface for two or three meters or more, corky; surface white or gray to “light pinkish cinnamon,” finely tomentose, azonate or indistinctly zonate, margin thin, sterile below, often becoming blackish; context white or “light buff,” 1–6 mm. thick, hyphae in radial arrangement; tubes at first whitish then gray to black, 0.5–3 mm. in length; mouths concolorous with the tubes, 5–8 to a mm., round to angular; basidia 4-spored, 4–5  $\times$  9–14  $\mu$  in diameter; spores hyaline, smooth-cylindric to cylindric-ellipsoid, seldom allantoid (curved), 3–5  $\times$  1.5–2.5  $\mu$ ; hyphae rarely branched, thick-walled, 4–6  $\mu$  in diameter; cystidia none.

*Allied species.*—The nearest allied polypore to *Polyporus adustus* is *Pol. fumosus*. The differences between the two plants are mostly relative. The mouths of *Pol. adustus* are somewhat smaller, i.e. 5–8 to a mm., whereas in most specimens of *Pol. fumosus* they are 3–5 to a mm. The tubes may be longer than those recorded for *Pol. adustus*, and the fruiting body itself is thicker. It is known that *Pol. adustus* has deep smoke-colored pores when growing, whereas *Pol. fumosus* has white pores that turn smoky in drying. *Pol. crispus* (Pers.) Fr., which is regarded by many as a good species but which is here classed as a synonym of *Pol. adustus*, is said to differ from the latter only in the radially appressed fibrils on the surface of the pileus and the crisped or wavy margin of the pileus (29).

A few specimens of this plant have been collected on conifers. These are so thin and possess such a stereum-like margin that *Polyporus pallescens* Karst. is suggested. That species, however, does not possess dark-colored tubes.

It is usual for specimens entirely resupinate to separate at the margin upon drying, so that one can distinguish this polypore from a true poria. In Oklahoma and elsewhere in the Southwest, however, the plant may become and remain entirely resupinate, so that an

abundance of material in various stages of growth is necessary before an accurate diagnosis can be made. *Polyporus adustus* is more likely to occur in the resupinate stage in the Plains states than farther east.

*Habitat.* — *Abies balsamea*, *Acer Negundo*, *A. rubrum*, *A. saccharinum*, *A. saccharum*, *Aesculus californica*, *Alnus oblongifolia*, *A. rubra*, *Betula lutea*, *B. neo-alaskana*, *B. papyrifera*, *B. papyrifera occidentalis*, *Carpinus caroliniana*, *Celtis* sp., *Cercis canadensis*, *Citrus* sp., *Cornus florida*, *Eucalyptus globulus*, *Fagus grandifolia*, *Gleditsia* sp., *Halesia carolina*, *Hicoria ovata*, *Ilex opaca*, *Juniperus virginiana*, *Larix occidentalis*, *Liquidambar styraciflua*, *Liriodendron tulipifera*, *Magnolia virginiana*, *Nyssa sylvatica*, *Ostrya virginiana*, *Picea excelsa*, *P. rubra*, *Pinus ponderosa*, *P. Strobus*, *Platanus occidentalis*, *Populus balsamifera*, *P. deltoides*, *P. grandidentata*, *P. tremuloides*, *P. trichocarpa*, *Pseudotsuga taxifolia*, *Prunus demissa*, *P. pennsylvanica*, *P. serotina*, *Quercus alba*, *Q. borealis maxima*, *Q. Garryana*, *Q. velutina*, *Rhus taxicodendrum*, *Robinia pseudoacacia*, *Rubus* sp., *Salix alba vitellina*, *S. nigra*, *Syringa vulgaris*, *Thuja occidentalis*, *T. plicata*, *Tilia glabra*, *Ulmus americana*, *Viburnum Sargentii*, *Vitus* sp.

*Distribution.* — Alberta, British Columbia, New Brunswick, Manitoba, Nova Scotia, Ontario, Quebec, Saskatchewan; Alaska; Alabama, Arizona, Arkansas, California, Colorado, Connecticut, District of Columbia, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, Tennessee, Texas, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming.

*Occurrence.* — The fungus is known not only over much of North America and Europe, but also in such widely separated places as Cuba, the Argentine Republic, Patagonia, and the Philippines. In Australia it has been reported from New South Wales and Queensland (28). In the United States it is less prevalent in the areas west of the one hundredth meridian.

*Polyporus adustus* attacks over thirty different genera of trees. It is most common on hardwoods, especially species of *Populus*, throughout the continent. It occurs occasionally on conifers. *Abies balsamea*, *Pinus ponderosa*, *Larix occidentalis*, *Thuja plicata*, and

*Pseudotsuga taxifolia* are reported America substrata; it is known on *Picea excelsa* in Sweden (31). The fruiting bodies are usually somewhat thinner than those that appear on hardwood timber and at times are almost "stereum-like." It causes decay in standing hardwoods injured by fire.

**Cultures.**—*Polyporus adustus*, one of the most common of the polypores, has not been studied extensively in cultures by Americans; apparently it exhibits an optimum growth at 25° C. Cartwright and Findlay (7) report about 25° C. for the English isolate, and it is therefore placed in the Intermediate-Temperature Group of Humphrey and Siggers (18), that is, the optimum is between 24° and 32° C. Cart-

TABLE I

GROWTH OF POLYPORUS ADUSTUS AND POL. FUMOSUS COMPARED

Species	Temperature in centigrade					
	15°	20°	25°	27°	30°	35°
<i>Pol. adustus</i> . . .	2.8	7.9	8.0	7.8	3.5	0
<i>Pol. fumosus</i>	2.5	5.1	7.4	6.4	1.5	0

wright and Findlay also cultured the closely related *Pol. fumosus*, which make slightly less growth at various temperatures than *Pol. fumosus*, as is shown by results given in Table I. It produces a smooth soft white (or slightly yellowing on aging) cottony-woolly growth. The odor is faintly fragrant. A few swellings of the chlamydospore type are present, and clamp connections occur (7).

The fungus gives a positive reaction to tannic-acid medium.

**Decay.**—*Polyporus adustus* brings about a white, mottled aspect, which often extends into the heartwood of a tree or a log. The infected wood gradually becomes lighter in color and weight than that which is sound. White areas appear to run radially throughout the wood during the early period of decay and become more conspicuous as fungus activity progresses. No black lines or zones are formed.

Development of saprot caused by this fungus in red gum has been described by von Schrenk (28) with reference to logging and milling practices. Where red gum is felled for its lumber the logs are sawed in the woods and are skidded to the bank of a stream for either floating or rafting later on, or hauled by truck or railroad to the mill. Less decay takes place in logs that are hauled to the mill and sawed at

once. The boards dry out in the piles "to such an extent that the growth of the fungus is made impossible." If, however, the logs are rafted, saprot will result in from one to several weeks after the timber has been cut, depending upon the season of the year. Green red-gum logs sink when placed in water, so that it is customary to pile them along stream banks for some months until they have dried out to such a degree that they can be rafted by the aid of cottonwood or other lighter logs. Rafting or floating takes place during December and January, when a sufficient amount of water is available. Summer-cut logs manufactured into boards show decay, which may extend from both ends of the log throughout the sapwood for distances ranging from several inches to several feet.

Freshly sawed boards that are infected with *Polyporus adustus* are characterized by streaks of various colors. These streaks are light orange in the region of first change. When the wood has decayed further, affected areas become straw-colored or whitish. It is only after the fungus has grown into the wood for a considerable distance (two or three feet), however, that a marked disintegration results.

According to von Schrenk, it is not unusual to find more than 75 per cent of freshly sawed boards in one pile forming fruiting bodies within two weeks after the planks are piled in stacks.

*Prevention of Decay.*—Saprot in red gum caused by *Polyporus adustus* may be prevented by shortening the drying period in the woods, either by hauling the logs by truck or rail or by reducing the moisture in the log. Von Schrenk (28) finds that the drying may be accomplished by leaving the felled gum trees in the forest and postponing the sawing until the leaves are thoroughly dry. The amount of water evaporated by the leaves may be sufficient to permit floating the logs.

Saprot may likewise be retarded by end coatings of the logs. Wherever possible, freshly cut logs, especially those that are cut during spring and summer months, should be peeled.

*Polyporus biformis* (Klotsch) Berk., *Linnaea*, 8: 486. 1833

(Plate VII)

*Polyporus molliusculus* Berk., *Lond. Journ. Bot.*, 6: 320. 1847.

*Polyporus carolinensis* Berk. (ex Murrill), *Journ. Bot. and Kew Misc.*, 1: 102. 1849.

*Polyporus chartaceus* Berk. (ex Murrill), *Journ. Bot. and Kew Misc.*, 1: 103. 1849.  
Grevillea, 1: 53. 1872.

*Polyporus scarrosus* B. & C. (ex Murrill), Grevillea, 1: 52. 1872.

*Polyporus pallidocervinus* ex Lloyd, Synopsis of the Section Apus of the Genus *Polyporus*, p. 383. 1915.

*Polystictus bififormis* (Fr.) Sacc., Syll. Fung., 6: 240. 1888.

*Coriolus bififormis* (Klotzsch) Pat., Tax. Hymen., p. 94. 1900.

Fructification sessile, effused-reflexed or resupinate; pileus whitish, drying alutaceous-coriaceous or often rigid when dry, 1–5 × 1–6 × 0.2–1.2 cm. or resupinate; surface whitish to “pinkish buff,” “cinnamon buff,” “Sabal brown,” with radiating fibrils; margin thin; context white, 1–6 mm. thick; tubes white or whitish, mostly 2–6 mm. long; mouths white to yellowish or light brown, i.e. white to “cinnamon buff,” sometimes drying to “cinnamon brown,” large, commonly breaking up to form teeth, 1–2 to a mm., no cystidia, spores hyaline, smooth-cylindrical, 6–8 × 2–2.5  $\mu$ , hyphae 3–4  $\mu$  in diameter.

*Allied species.* — *Polyporus bififormis* is closely allied to *Pol. pubescens*. *Pol. bififormis* differs from *Pol. pubescens* in that the mouths in *Pol. bififormis* are large (1–2 to a mm.), whereas in *Pol. pubescens* they are smaller, i.e. 3–4 to a mm.

*Habitat.* — *Acer rubrum*, *A. saccharum*, *Alnus tenuifolia*, *Arbutus Menziesii*, *Betula lenta*, *B. lutea*, *B. neo-alaskana*, *B. papyrifera*, *Carpinus* sp., *Fagus grandifolia*, *Fomes fomentarius* (fruiting body), *Fraxinus nigra*, *Hicoria cordiformis*, *H. glabra*, *Juglans cinerea*, *Liquidambar Styraciflua*, *Liriodendron Tulipifera*, *Lithocarpus densiflora*, *Nyssa* sp., *Picea mariana*, *Populus grandidentata*, *Prunus pennsylvanica*, *Quercus alba*, *Q. borealis maxima*, *Q. Emoryi*, *Q. Garryana*, *Q. marilandica*, *Q. rubra*, *Q. texana*, *Q. velutina*, *Q. virginiana*, *Robinia pseudoacacia*, *Salix* sp., *Tilia* sp., *Ulmus americana*, *Umbellularia californica*.

*Distribution.* — British Columbia, Manitoba, Nova Scotia, Ontario, Quebec; Northwest Territories, Yukon Territory; Alaska; Alabama, Arkansas, California, Connecticut, Delaware, District of Columbia, Florida, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, New Hampshire, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, Tennessee, Texas, Vermont, Virginia, West Virginia, Wisconsin.

*Occurrence.* — This common plant in America occurs rather infrequently in Europe. Lloyd (21) points out that *Polyporus bififormis* grows in Cuba (but is there called *Polyporus pallidocervinus*) and that it is the same as the ubiquitous American species. It is rare in Africa.

I have found *Polyporus biformis* more abundant in Ozark County, Arkansas, than elsewhere in the United States.

*Poria ferox* Long & Baxter, Pap. Mich. Acad. Sci.,  
Arts, and Letters, 25 (1939) : 149. 1940

(Plates VIII-IX)

Baxter, *op. cit.* Sections pertaining to description, allied species, distribution, and decay are presented.

**Cultures.**—Isolated from *Juniperus virginiana* from Mountain View, Arkansas. Young cultures of *Poria ferox* are snow white and cottony in texture. The best growth of the rapidly growing fungus, as shown by the average of six tests, takes place at approximately 30° C. (19.4 mm. in 7 days and 36.8 mm. in 14 days). The plant develops almost equally well, however, at 25° C. (15.0 mm. in 7 days and 36.2 mm. in 14 days). Growth at 35° C. is rapid compared to that of a large number of resupinate polypores (12.6 mm. in 7 days and 30.0 mm. in 14 days).

This fungus, which attacks coniferous standing trees in nature, may be cultured on both coniferous and frondose woods. The mycelium, however, grows somewhat more profusely on red-gum than on white-pine test blocks.

*Fomes Earlei* (Murr.) Sacc. & D. Sacc.,  
Sacc. Syll., 17:119. 1905

*Pyropolyporus Earlei* Murr., Bull. Torr. Bot. Club, 30:116 1903

**Fructification** undulate, woody, attached by a broad base, approximately 6 × 13 × 17 cm., surface concentrically sulcate, very rimose, "olive brown" or "clove brown," at length grayish black; margin broad, obtuse, brown "cinnamon buff" to "clay color," tomentose; context woody, brick red, "cinnamon rufous" to "kaiser brown"; concentrically banded with darker lines, only approximately 0.5 cm.; tubes unevenly stratified, 0.5–0.75 cm. long each season, mouths yellowish brown, "chamois" to "Sayal brown"; 1–2 to a mm.; circular; spores ellipsoid, smooth, thick-walled, ferruginous 7–8 × 9 μ (Murr.).

**Distribution.**—Arkansas, New Mexico.

**Habitat.**—*Juniperus monosperma*, *J. sabinoides*, *J. utahensis*, *J. virginiana*.

**Occurrence.**—Murrill (23) reports that in 1908 the fungus was known

only from the type locality. Since then so many collections have been made in the Southwest that it is regarded primarily as a southwestern fungus. It is here reported on red cedar in the Arkansas National Forest areas near Mountain View. *Fomes Earlei* occurs on standing green timber only.

*Cultures*.—Isolated from standing *Juniperus virginiana*, Mountain View, Arkansas.

*Fomes Earlei* is characterized by its bright brown chamois skin-like mycelium, which is "primuline yellow," and commonly exhibits "claret brown" droplets on the surface.

The fungus is the slowest-growing polypore in the Michigan collection of cultures. Mycelium does not develop on the agar in petri-dish cultures at 25°, 30°, or 35° C. in 7-day tests, and the extent of its radial development averages only 2 mm. at 25° and 30° C. in a 14-day period. No growth occurred at 35° C.

This fungus, which attacks coniferous standing trees, may be cultured on both coniferous and frondose woods. The mycelium, however, grows somewhat more profusely on white-pine than on red-gum blocks.

*Decay*.—*Fomes Earlei* causes a "yellow rot," producing long tubelike holes in the heartwood.

*Remarks*.—The description is based upon that presented by Murrill.

*Fomes Earlei* is not a resupinate polypore, but because of its relationship to other brown resupinate members of the *Fomes* and "Fomitipora" groups, it is included here.

*Fomitoporella melleopora* Murr., North Am. Flora,

Pt. I, p. 13. 1907

Baxter, Dow V., Pap. Mich. Acad. Sci., Arts, and Letters, 18 (1946) 191-212 1948  
Sections pertaining to description, allied species, habitat, distribution, and occurrence are presented

*Cultures*.—Isolated from *Populus tremuloides*, Michigan National Forest, East Tawas, Michigan.

*Poria melleopora* is characterized by its varying appearance in culture at different temperatures. In two-week-old cultures at 25° C. the mycelium, unlike that of the majority of brown resupinates, is somewhat silky, white at the margins, and "aniline yellow" nearer the inoculum. In contrast, cultures kept at 30° C. are cottony in texture and uniformly "cartridge buff" to "cream buff" and more nearly



resemble other species of polypores — *Fomes Everhartii*, for example. The cultures grown at 25° C. suggest those of *Polyporus radiatus*, except that agar does not turn dark in these two-week-old tests of *Poria melleopora*. The cottony texture is retained in cultures kept at 35° C., but the color is lighter and generally whitish instead of light brown.

*Poria melleopora* grows more rapidly at 30° C. in 7- or 14-day-old cultures than at 25° C. or 35° C., but, unlike many of the resupinate forms, it exhibits a greater growth at 35° C. than at 25° C. at the end of either a 7- or a 14-day test.

This fungus, which attacks hardwoods in nature, may be cultured on both frondose and coniferous woods. The mycelium, however, grows only slightly more profuse on red-gum blocks than on white-pine test pieces.

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*Poria quercinum* sp. nov. on *Quercus stellata*, Branson, Missouri





*Poria crustulina varophylla* var. nov. on *Lorreyia californica*, vicinity of Muir Woods, California





*Poria Cocos* on cornstalk, F. A. Wolf; Herbarium Mycological Collections, U. S. Bureau Plant Industry,  
Beltsville, Maryland





# THE HISTORY AND Present STATE OF VIRGINIA, In Four P A R T S.

- I. The History of the First Settlement of *Virginia*, and the Government thereof, to the present Time.
- II. The Natural Productions and Conveniences of the Country, suited to Trade and Improvement.
- III. The Native *Indians*, their Religion, Laws, and Customs, in War and Peace.
- IV. The present State of the Country, as to the Policy of the Government, and the Improvements of the Land.

*By a Native and Inhabitant of the P L A C E.*

L O N D O N :  
Printed for R. Parker, at the *Uncore*, under the *Piazza's*  
of the *Royal-Exchange*. MDCCV.

The earliest reference to the tuckahoe in North American literature occurs in the last line of page 15 of the first edition (1705) of *The History and Present State of Virginia*, by Robert Beverly. From a copy in the William L. Clements Library, University of Michigan

## Present State of VIRGINIA 15

They have no Salt among them, but for seasoning, use the Althes of Hickory, Stickweed, or some other Wood or Plant, affording a Salt Jlh.

They delight much to feed on Roasting-ears; that is, the *Indian* Corn, gathered green and malky, before it is grow'd to its full bigness, and roasted before the fire, in the Ear. For the sake of this Dyet, which they love exceedingly, they are very careful to procure all the several sorts of *Indian* Corn before mentioned, by which means they contrive to prolong their Season. And indeed this is a very sweet and pleasing Food.

They have growing near their Towns, Peaches, Strawberries, Cuslawes, Melons, Pompons, Maracks, &c. The Cuslawes and Pompons they lay by, which will keep several months good after they are gathered; the Peaches they save, by drying them in the Sun, they have likewise several sorts of the *Physick*.

In the Woods, they gather Chinapins, Chestnuts, Hickories, and Walnuts. The Nernels of the Hickories they beat in a Mortar with Water, and make a White Liquor like Milk, from whence they call our Milk *Hickory*. Hazlenuts they will not meddle with, tho they make a Shift with Acorns sometimes, and eat all the other Fruits mentioned before, but they never eat any sort of Herbs or Leaves.

They make Food of another Fruit call'd *Curtanummas*, the Fruit of a kind of Arum, growing in the Marthes. They are like Boy'd Peas, or Capers to look on, but of an insipid earthy taste. Captain Smith in his History of *Virginia* calls them *degluchnammas*, and *Theod. de Bry* in his Translation *Sesiphanummas*.

Out of the Ground they dig Turneps, Farthurs, Wild Onions, and a Tuberous Root they call *Tuckahoe*, which while crude is of a very hot and violent





*Polyporus balsameus* (resupinate) on *Abies balsamea*, Gander Lake, Newfoundland





*Polyporus adustus* (resupinate) on *Juglans nigra*, Jasper, Arkansas





FIG. 1. *Polyporus biformis* on *Quercus marilandica*, Jasper, Arkansas



FIG. 2. *Polyporus biformis* (resupinate) on *Quercus marilandica*,  
Jasper, Arkansas





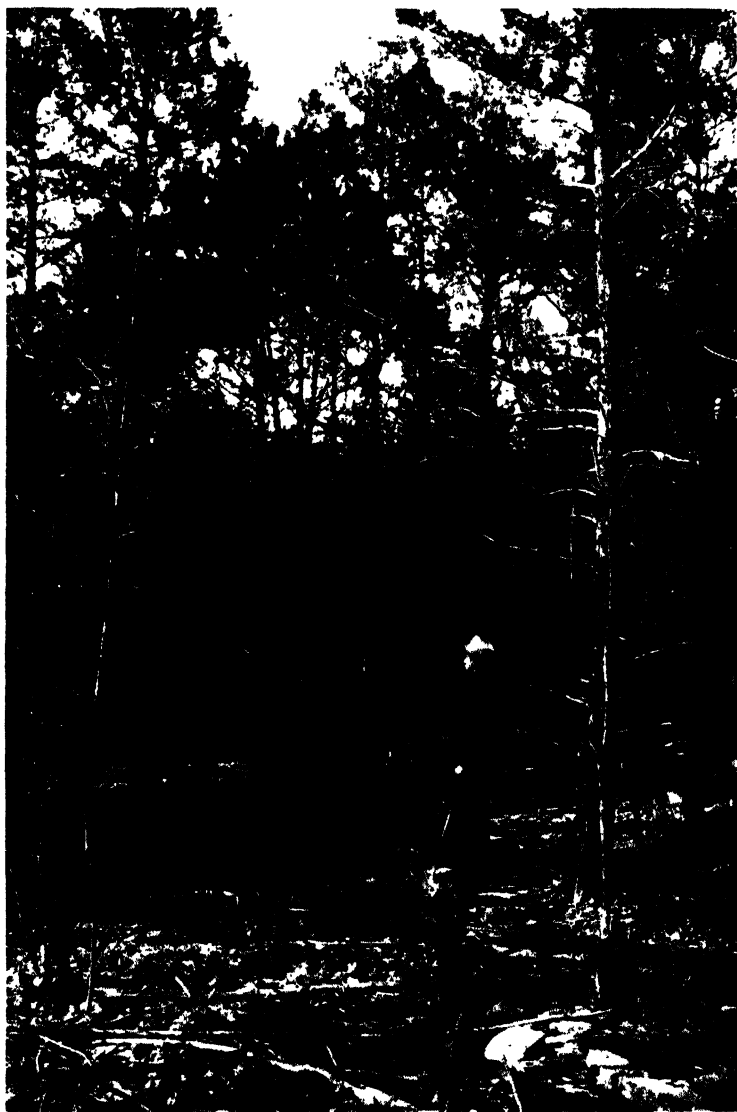
BAXTER

PLATE VIII



*Portia jerox* Long & Baxter on leaning trunk of live *Juniperus virginiana*, Mountain View, Arkansas





Juniper-oak association, Mountain View, Arkansas, habitat for *Poria ferox* Long & Baxter on juniper slash and wounded live juniper



# FORESTRY IN SOIL CONSERVATION

ALBERT F. DODGE

**W**HEN a farmer applies to the local soil-conservation district for assistance he generally does so because he is confronted with some land-management situation with which he cannot cope or which he does not understand. Perhaps his legume hay yields are slowly decreasing on the good twenty despite assurances that legumes build up the soil. Possibly he wishes to bring a piece of practically idle muck land into production, but he is not certain that the soil is worth the expense of draining. He wants a windbreak for the farmstead and needs some guidance in the choice of species for the planting.

These are immediate problems which bring the farmer to the district for assistance. Prior to this problem he has long recognized differences in the various fields on his farm. Some fields which once grew acceptable cash crops are now thin or rocky, and their use may have been changed to the growing of hay or to pasturing. Certainly the best land, or a portion of the best, will be in row crops. These uses have come about largely for convenience, without much regard for soil structure, depth of topsoil, and availability or losses of plant nutrients.

If a farmer's application for assistance is approved by the governing body of the soil-conservation district, a conservationist from the Soil Conservation Service starts working with him. The farm boundaries are marked on an aerial photograph, and this information is turned over to the soil scientist, another technical employee assisting the local district. This scientist takes the aerial photograph and records the kinds of soil, the degree of slope, and the extent of erosion for the entire farm. This survey is a complete physical inventory of the farm-land conditions. With the inventory as a base, the soils on the farm are classified according to the best uses to which they may be put with least loss through erosion.

## LAND CAPABILITY CLASSES

On the basis of these factors lands are grouped into eight classes with respect to the degree of hazard in their use. These land classes

provide an orderly guide for a permanent agriculture. If farm land is worked more intensively than is indicated in the following description, deterioration is inevitable (1).

### *Land Suitable for Cultivation*

*Class I.* — Very good land that can safely be cultivated with ordinary good farming methods. It must be capable of producing moderately high yields of climatically adapted crops, and be free from stones which would impede cultivation. It is not subject to overflow or serious erosion. It must be well drained or capable of being drained to permit at least moderate yields.

*Class II.* — Land differing from that in Class I in that cultivation requires the adoption of some simple practices if the soil is to remain permanently productive. Some of these practices are: contour tillage, strip cropping, cover crops, crop rotation which includes grasses and legumes, one or two simple terraces or drainage ways, and the correction of inherently low fertility by the application of fertilizers.

*Class III.* — Moderately good land suitable for cultivation only when cultivation is supported by intensive conservation practices. Such practices include strip cropping, with narrow bands of annual crops alternating with strips of grasses and legumes; long crop rotation with clean-tilled crops held to a minimum; intensive terrace systems with outlets; diversion ditches to carry off excess water; and drainage systems that are difficult to install and maintain.

All cropland in Classes I, II, and III may require replacement of nutrient elements that have been removed by crops or lost by leaching. The need for soil treatments increases progressively in these three classes in order to maintain organic matter and to return moderate to high yields.

### *Land Suitable for Limited Cultivation*

*Class IV.* — Steep land areas severely eroded or susceptible to deterioration and soil so imperfectly or excessively drained as to be unsuitable for row crops. This class is adapted to a grain crop every five or six years, which is to be followed by hay or pasture.

### *Land Suitable for Permanent Vegetation*

*Class V.* — Land not subject to soil losses under ordinary use; in general, it is flat and too wet, cold, or stony for any cultivation. It will produce forage or wood crops.

*Class VI.*—Land that because of moderately steep slopes can be used permanently only for pasture or woods. On most farms this class will be pasture capable of being renovated, and under proper management will continue to supply forage for livestock.

*Class VII.*—Land that includes steep slopes, broken topography, thin or rocky soils, and badly gullied areas; requires severe restriction in use. In the humid regions of the East this class of land should be utilized for the production of wood crops because its restricted use and limited carrying capacity as pasture do not ordinarily warrant the expense of establishing and maintaining stands of forage plants.

*Class VIII.*—Primarily waste land and not suited for the production of any useful vegetation, but may have possibilities for wildlife and recreation. It often consists of rocky outcrops, barren land, or permanently wet marshes that cannot be drained.

With the delineation of the various fields or portions of fields into capability classes, it is possible to make sound land-use recommendations to the farmer. His crop and livestock needs can be adjusted accordingly, and his soil capital maintained. When site conditions require the protection of a forest cover, tree planting or woodland-management recommendations are given.

#### RETURNS FROM FARM WOODLAND

If a coöperator has land in Class I, II, III, or IV that is in woods or land best suited to remain as woods (Classes V, VI, VII), it is only natural that he should inquire about the probable returns from farm woodland operations. Farm-management studies have long recorded costs and returns for many farm enterprises. In the Middle West, at least, the farm woodland, as a part of the farm accounts, has largely been ignored. Recently the farm planner's fund of information on the returns from farm woodland work has been considerably enhanced.

In a report of 89 farm woodland operations in Ohio, Indiana, Michigan, Minnesota, and Iowa, Locke (2) and several resident farm foresters summarized 339 record years of income and expense. These data cover the six-year period 1940–45, during which the Soil Conservation Service administered part of the Norris-Doxey Act. Individual account books were carefully checked for volume differences, so that the records included in the summary reflect only regulated timber harvest. Heavy cut was one of the reasons why the 89 acceptable records represented only 30 per cent of all the records taken. All acceptable records were assembled according to average annual net return per acre and divided

into three groups, those with high, medium, and low incomes. The averages of income and expense for each group are presented in Table I. These data may be considered typical of three kinds of farms that are engaged in woods work with varying success.

It will be noted that wood products such as fuel, posts, poles, and lumber for the farm comprise a substantial part of the total value of

TABLE I  
AVERAGE ANNUAL INCOME AND EXPENSE OF EIGHTY-NINE FARM WOODLANDS

Income and expense	High income from 25 woods (average)	Medium income from 39 woods (average)	Low income from 25 woods (average)
1. Income, home use . . . . .	\$156.14	\$142.34	\$107.63
2. Income, sales . . . . .	434.42	16.96	14.62
3. Income, stumpage . . . . .	103.46	24.66	2.60
4. Total gross income . . . . .	694.02	183.96	124.85
5. Expenses, noncash . . . . .	151.00	57.22	62.28
6. Expenses, cash . . . . .	60.15	24.00	19.90
7. Taxes . . . . .	14.21	8.13	10.01
8. Interest on investment (3%) . . . . .	111.54	37.08	46.27
9. Total expenses . . . . .	336.90	126.43	138.46
10. Net income . . . . .	357.12	57.53	— 13.61
11. Net income per acre . . . . .	8.50	1.92	— 0.23
12. Interest on investment . . . . .	12.6%	7.6%	2.1%
13. Returns per hour of labor . . . . .	1.33	0.67	0.26

products cut annually. Stumpage sales were handled as a separate item under income. The figure for them is deducted from income in computing return per hour of labor (line 13), since the coöperator's labor is not involved.

The returns for the use of the woodland are shown as net income per acre, interest on investment, and as returns per hour of labor. This last item is particularly valuable to the farm planner in encouraging the farmer coöperator to put his time into the woodland. Most farmers have worked for hourly wages, and income expressed in such terms has real meaning.

Poor tools, inadequate equipment, lack of experience and skill, and the fact that many of the farmers were starting woods work for the first time — all tended to make the net return low. Indeed, returns were negative for a number of farms. In some cases the farm forester actually advocated work without positive return value. The planting of



pine in openings and certain thinnings are examples of nonremunerative work suggested to improve woodland conditions.

The analysis of the individual records revealed the fact that an operator's managerial ability to utilize fully his labor in getting out woods products is more important than site quality as an income factor. If he ignores the woodland work, he loses the income regardless of site conditions.

The records of income from these eighty-nine farm woodlands indicate that time spent in the woods influences income. Farmers with high incomes from such operations put in more hours in their woods than those with lower incomes (see Table II). In other words, more work in the woods means higher income.

TABLE II  
TIME SPENT IN THE WOODLAND BY INCOME GROUPS

Income group	No. of acres in woodland (average)	No. of hours spent in woods (average)	Hours per acre (average)
High .....	42	287	6.8
Medium .....	30	125	4.1
Low .....	58	153	2.6

TABLE III  
SIZE OF WOODLAND AND NET INCOME PER ACRE

Number of acres	Number of farms	Net income per acre (average)
4-20 .....	33	\$4.07
21-40 .....	31	3.70
41-185 .....	24	3.21

If a farmer attempts to operate more woods area than he can efficiently handle with his available labor, he either sells stumpage or allows the growth to accumulate. In either case the woods income suffers. Table III suggests that the size of the farm woodland is apparently correlated with income.

From the foregoing discussion it is evident that for the first time farm planners assisting soil-conservation districts have available income and expense data for the operation of farm woodland on a sound, regu-

lated basis. With this information they are encouraging Michigan farmers having woodlands to put their off-season labor into the harvesting of woods products. If the coöperator has trees of various sizes in his woodland and if he will regularly and wisely devote his time to harvesting and improving the woodland, he can be assured of an income which will be as good as or better than that from most other farm operations.

#### REFORESTATION

Tree planting by soil-conservation district coöperators is largely confined to evergreens—pines and some spruce. In most instances the actual work is done by the coöperators themselves. They follow the planting suggestions of the farm planner of the Soil Conservation Service. Stock for such plantings is obtained from the Michigan Conservation Department, from the Michigan State College Forestry Department Nursery, or from the local soil-conservation district.

Trees have been planted on 22,421 acres of eroded fields and gullies, land in Class VII. This has been done since 1938, when Michigan's first soil-conservation district, the West Ottawa Soil Conservation District, was organized. In 1946 some 3,576 acres were planted, but 31,930 acres of Class VII land on farms still remain to be planted.

Along or near the Lake Michigan shore tree planting has been recommended for 6,317 acres of dune or beach sand. Already 2,554 acres of this have been set to trees, 215 of which were planted in 1946. Sometimes it is necessary to stabilize the planting site with brush or beach grass prior to planting the pines. This serious erosion condition has been successfully controlled by individual coöperators working with the soil-conservation district.

To date coöperators and planning technicians have agreed on the use of 1,268 acres for windbreaks, of which 954 acres have already been set out.

Farmer coöperators in Michigan, operating more than 495,000 acres, have planted 25,929 acres to trees. Preliminary estimates of Michigan farm land best suited for tree planting, as taken from conservation survey data, are placed at 654,000 acres.

An interesting development in connection with this farm tree planting is the nursery operated by the soil-conservation district. The directors of three soil-conservation districts serving parts of Muskegon and Ottawa counties have been raising several kinds of pines from seed.

These seedlings are planted out in nursery rows for one or two seasons. Modified celery planters make this possible with a minimum of labor. Fully developed transplant stock is thus available within the district for any coöperator at a moderate cost without the hazards of common carrier shipment.

Seven other soil-conservation districts are operating lining-out nurseries at the present time. The advantages of this procedure are being considered by seven additional soil-conservation districts. During the 1945-46 planting season the ten active nurseries provided 1,273,000 transplanted conifers, which were largely pines. This was more than one third of the 3,398,000 trees planted by district coöperators. The rest of the stock came from state and federal nurseries.

The success of these plantings in Michigan may be attributed to the following factors:

1. Several soil-conservation districts actively encourage coöperator tree planting by growing transplant stock locally.
2. Nearly all Michigan soil-conservation districts obtain grants of stock from the Soil Conservation Service to encourage tree planting.
3. The coöperator obtains on the ground help from the resident planning technician of the soil-conservation service in choosing the proper trees for the planting site and in methods of caring for and planting the stock.

The plantings made by coöperating farmers in Michigan have generally been quite successful. For the country as a whole, according to Preston (3), soil-conservation district coöperators have enjoyed an average tree survival of better than 85 per cent.

U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE  
ALLEGAN, MICHIGAN

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# SOME RESULTS OF SELECTION CUTTING IN THE EBER WHITE WOODS, ANN ARBOR, MICHIGAN

LEIGH J. YOUNG

*University of Michigan*

HAROLD F. SCHOLZ

*Lake States Forest Experiment Station*

**I**N 1915, when the University of Michigan came into possession of the Eber White Woods near Ann Arbor, they represented a remnant of southern Michigan hardwood forest, modified to some extent by cutting, which had removed a number of the larger and, probably, more valuable trees. The condition of the stand at that time indicated that the area had not been grazed for at least a considerable period. Possibly it had never been grazed. There was also no evidence of damage from fire.

Except for three small wet depressions and a little Washtenaw loam in the northwest corner, the soil is Miami silt loam. As this is a better soil than that of the average woodlot in this locality, the stand has a more complex composition. Among the trees of merchantable size oaks and hickories predominated. White ash, basswood, sugar maple, and elms were less abundant, but were well represented throughout the stand. Other species occurred in much smaller numbers and included black walnut, butternut, black and blue ash, black cherry, yellow poplar, aspen, sassafras, Kentucky coffee tree, cottonwood, red maple, and junberry. A complete list of the common and scientific names of the species is given at the end of this paper.

At the time of acquisition there was an understory of small trees, consisting almost entirely of ironwood, with a sprinkling of blue beech, dogwood, and hawthorn. In the southern half of the woods this understory was so dense throughout that it had almost entirely prevented the reproduction of other species. But in the northern portion it was more open and irregularly distributed.

The stand was decidedly uneven-aged, but without an equal distribution of age classes. The large-pole class was particularly deficient in relation to the others. All diameter classes were present up to a maximum of 44 inches. The best dominants reached a height of 90 feet.

#### FORM AND CONDITION OF TREES

The number of trees with pronounced crook was larger than desirable. In fact, they were so numerous that they almost obscured the presence of the many straight, well-formed individuals.

In general, the trees of saw-timber size were poorly cleaned, and this was particularly true of the trees above 30 inches in diameter. The crowns of these oldest trees were very wide, with heavy branches. A clear length of more than two 16-foot logs was exceptional. Many of the largest individuals were overmature and had become stag-headed.

Heart rots had caused defect to an average amount of about 20 per cent, though in some of the veterans, ranging in age from 200 to 300 years, the heartwood was practically all decayed.

#### CUTTING POLICY

As the original plan was to operate on a ten-year cutting cycle, the area was divided into ten compartments of 4.3 acres each. The compartments were to be cut successively at the rate of one each year. However, after compartments 1 to 5 inclusive had been cut, it appeared desirable to cut again in these compartments to secure a more rapid reduction in the amount of ironwood and a quicker release of reproduction of the more valuable species. Defective trees in need of salvaging were cut at the same time. Compartment 6 received its first cut that same year. Since that time cutting has been done in two compartments each year, with the heavier cuts made at ten-year intervals. Present conditions are such that the lighter cuts at the intermediate five-year intervals can be abandoned.

The earlier cuts were made on a single-tree selection basis, with the major emphasis on stand improvement in all age classes and with no attempt to secure a strict regulation of volume removed. After each compartment has been marked for cutting, the diameters of all trees have been measured, with separate tallies of the trees cut and those to be left. The minimum diameter measured has been a full inch. This procedure has provided a check on the relation between the growth in

basal area and the amount cut at the five-year intervals, and has also made it possible to learn at what rate reproduction was working up into the larger size classes.

Later, whenever the distribution of the larger trees has been favorable, cutting of groups has been practiced to reduce logging damage to young growth and to provide better conditions for the reproduction of the less tolerant, light-seeded species.

There has been one deliberate violation of good silviculture in that a considerable number of the very large, overmature oaks have been retained until there was very definite evidence that they were decadent. On compartment 3, however, all trees of this class have been cut.

Trees of weed species have not been cut unless they were large enough to produce salable wood or were interfering with the development of individuals of better species. A complete removal of the weed species would be expensive and would frequently result in too much reduction in the crown density needed to maintain good forest conditions. Small trees of weed species growing under the crowns of large trees are left undisturbed until the large trees have been cut.

One objective of the cutting policy has been to increase the volume of the growing stock as much as possible and to improve its quality both in composition and in the character of individual trees. Another has been to maintain conditions favorable to adequate reproduction. After the major part of the necessary improvement work has been completed, attention must be given to securing a better distribution of age classes. The conversion of a stand, such as this one was in 1917, into a well-stocked, high-quality, well-regulated woods by the use of the selection method is a discouragingly slow process.

Because of a good local demand for firewood, utilization has been very close, and slash disposal has not been a problem.

#### REPRODUCTION

With respect to the number of trees, reproduction has been more than adequate, but there has been a wide variation in the degree to which the various species are represented. A systematic study, with the use of milacre quadrats, was made in 1934.<sup>1</sup> This showed that 67 per cent of the trees less than 10 feet in height consisted of white ash, sugar maple, basswood, and black cherry. Ironwood and dogwood amounted

<sup>1</sup> Feeman, Abram L., "Study of Reproduction in the Eber White Woods," 1934. Unpublished manuscript.

to nearly 25 per cent. White ash led all the species in the number of trees and extent of distribution, with sugar maple second and black cherry and basswood practically tied for third place. There is no evidence of any material change since that time. On some areas reproduction of these species has entirely replaced the former understory of ironwood.

Although the oaks and hickories predominate among the older trees of the stand, reproduction of these species is almost negligible in amount. Several factors are responsible for this condition, but it is not known to what extent each one has operated. Close proximity to the city of Ann Arbor results in a heavy collection of the edible hickories and walnuts. Squirrels undoubtedly cause a further loss of seed of all the heavy-seeded species. Even if some of these seeds are left to germinate, the rather high density of most of the stand causes their early suppression. In some places white oak and hickories have reached sapling size, only to be driven out by the more rapidly growing ash, basswood, and cherry.

On a few small areas dense thickets of witch hazel and gray dogwood have caused a failure of reproduction.

At the time that management of the woods was started reproduction was lacking along the west and south boundaries on strips about a hundred feet in width. Most of the leaf litter was blown from these strips, and a rather heavy cover of grass had developed. An effort was made to establish a windbreak along these two boundaries by planting white and Scotch pines, but before these had grown enough to have any appreciable effect ironwood had started to invade the open areas. As it increased in density, the grass was shaded out, and other species were able to get started. At present these formerly open strips are almost completely restocked, though ironwood still predominates strongly.

#### EFFECTS OF CUTTING UPON STOCKING

In the following tables, which show the various effects of management, the data for compartments 1-5 and those for 6-10 are given separately, because the former group of compartments sustained a total of 27 cutting operations and the latter only 21.

The data in Table I show the effect of management upon the number of trees per acre by species in two classes — total number of all diameters and number of sawlog trees only. The figures given in the "1917" column do not represent the condition in all compartments in that year, but are averages of the number of trees present in the com-



partments of each group at the time of the first cut. In the same way the "1942" figures represent the situation at the time of the last cut.

In the entire woods there was an increase of 27.9 per cent in the total number of trees of the species listed as commercial, but a decrease of 1.4 per cent in the number of trees in the sawlog class. The total number of ironwood has decreased 38.5 per cent, but there are still 160 to the acre, compared to a total of 381 trees of the commercial species. This is not so bad as it looks, since most of the ironwood are small, have low vigor, and exert little influence on the remainder of the stand. The largest increases have been in ash, sugar maple, and black cherry, whereas red oak, elm, and hickory have decreased in number.

The extent to which figures alone fail to bring out the whole story in a case like this can be illustrated by those for basswood. In compartments 1-5 basswood has decreased by 8.7 per cent, but in compartments 6-10 it has increased by 11.4 per cent. One reason for this is that reproduction of basswood started earlier in the first group of compartments and has reached such a size and density that thinning has been necessary. In the second group of compartments little thinning of basswood reproduction has been done. Many of the old basswood that were sources of seed in the earlier years have been removed because of decadence, so that new reproduction of this species will be lacking in some portions of the area until the young trees now developing have reached the age of good seed production.

The figures in Table I also indicate the changes in composition in the stand. Taking the total number of trees of the commercial species only, we find that the percentage representation of each one at the beginning of operations was as follows: red oak, 12.5; white oak 5.2; ash, 11.2; basswood, 26.8; sugar maple, 5.4; elm, 18.4; black cherry, 4.4; black walnut, 1.2; and hickory, 14.7. In 1942 the percentages had become: red oak, 9.5; white oak, 4.3; ash, 23.0; basswood, 23.3; sugar maple, 10.0; elm, 10.5; black cherry, 8.2; black walnut, 1.3; and hickory 9.6. Of the trees of sawlog size in 1942 red oak made up 49.5 per cent, hickory, 20.6 per cent; white oak, 12.4 per cent; sugar maple, 5.3 per cent, a total of 87.8 per cent for these four species. But these same species composed only 33.4 per cent of the total number of trees of all sizes.

#### EFFECTS OF CUTTING UPON BASAL AREA AND VOLUME

By inspection of the data in Table III it will be found that cutting has caused a decrease in the basal area and gross volume of all size

classes, except the standards, and of the stand as a whole. Of the total decrease in basal area of the four size classes affected in that way the decrease in the veteran class constituted 61.2 per cent. If all the veterans had been removed at the first cut, the reduction in the total basal area might have been still greater, though part of it would have been offset by the more rapid growth of younger trees that could have occupied the areas covered by the veterans.

After the last cut the percentage distribution of the total cubic volume among the different size classes was: reproduction, 8.4; small poles, 7.0; large poles, 13.3; standards, 54.3; and veterans, 17.0.

#### DISTRIBUTION OF VOLUME BY SPECIES

Table IV shows the extent to which the oaks and hickories predominate in the total volume of the stand in both cubic and board feet. In total cubic volume of commercial species these species compose 75.2 per cent. This predominance of oaks and hickories occurs in all size classes, except reproduction and small poles. In reproduction, ash and basswood lead with percentages of 27.7 and 27.4, respectively. Basswood, hickory, elm, and ash are the chief species in the small-pole class, with percentages of 27.6, 17.3, 17.1, and 14.0, respectively. Ironwood is now only 3.5 per cent of the total cubic volume of the stand but still makes up 31.1 per cent of the volume in the reproduction class.

#### CHARACTER OF CUTTING

Some idea of the character of the cutting, especially the extent of work done in the smaller size classes, can be obtained from Table II.

Of the total number of trees cut, 83.5 per cent were in the reproduction class and 11.9 per cent were small poles. In cubic volume the cut in these two classes amounted to 23.2 per cent of the total. The largest part of the cut came from the veterans — 40.5 per cent. Standards ranked second with 28.2 per cent.

The distribution of the cut by species and size classes on the basis of number of trees removed is shown in Tables V and VI. This analysis brings out a number of important points.

Most of the red oaks cut were standards, whereas the heaviest cutting of all the other species, except black walnut and white oak, was in reproduction. In the case of ironwood over 90 per cent of the trees cut was in this class. More white oaks were cut in the small-pole class than in any other one.

Nearly 70 per cent of the trees cut in the reproduction class was ironwood. This species also led in small poles cut with 47 per cent. Hickory was second with 22.6 per cent. Hickory (36 per cent) and red oak (22.8 per cent) contributed the bulk of the cut in large poles. Of standards cut, red oak, hickory, and sugar maple made up over 70 per cent, but in the veterans class, white oak, basswood, and red oak, in that order, led in number of trees cut with a total of 82.6 per cent.

#### GROWTH IN BASAL AREA AND VOLUME

The growth figures as given in Table VII are not exactly encouraging, but in a stand cut and measured as this one has been, they do not represent the true results. They are included in this paper, however, to indicate how much in error this rather usual method of calculation can be in a case such as this one.

If the mean annual growth in basal area is computed for each compartment separately and for the period actually covered by the measurements, it is found that the best growth occurred in compartment 1, with a mean of 2.234 square feet, and the poorest in compartment 9, where the mean was 1.505. The mean for the entire woods was 1.799.

As a result of differences in the degree of cutting, the kinds of trees removed, weather conditions, and possibly other factors, there has been a marked fluctuation in growth in each compartment during each of the five-year periods. For example, basal area growth in compartment 2 varied as follows: 1924-28, 9.68 square feet; 1929-33, 11.175 square feet; 1934-38, 3.538 square feet. The basal areas cut from this compartment before each growth period were 5.25, 4.31, and 6.85 square feet respectively. In contrast, the similar figures for compartment 3 were: 1925-29, 9.13; 1930-34, 8.26; 1935-39, 9.01. In percentage basal area growth for a single five-year period has varied from 1.8 to 3.9. The best growth for a single five-year period was 17.81 square feet.

It is possible that the growth rate might have been improved by a more rapid removal of the mature and overmature trees and their replacement with young and vigorous ones. This was tried in compartment 3, where all the old and overmature trees were cut in 1929, except seven that ranged in diameter from 23 to 29 inches. Some of these trees were left because they were needed as a source of seed. Because of the time required for reproduction to become established in the openings made by cutting large trees and to develop to the point of contributing to the volume of the stand, it is still too early to get an

answer from this experiment. Further, owing to war conditions there has been no measurement of this compartment since 1939.

The woods has served as a study and experimental area in which students have been able to practice marking, observe the results of cutting operations, and gain some experience in the use of the axe and saw. Because all cutting has been done by student labor and carried out primarily as an educational project, the financial results have little value as a demonstration of what might be done with such a woods commercially.

#### SUMMARY OF RESULTS

Reproduction of the more valuable species has been sufficient to maintain good stocking and has consisted predominantly of a few light-seeded species.

The percentage of inferior species and of poorly formed, decadent trees has been considerably reduced.

The total gross volume of the growing stock has been temporarily decreased as a result of heavier cutting of the older trees in recent years.

A proper distribution of age classes has not been accomplished.

The mean annual increment has been low, owing partly to the presence of too many overmature trees and partly to the fact that many of the younger trees have not yet reached the age of rapid growth.

#### LIST OF SPECIES

COMMON NAME	SCIENTIFIC NAME
Ash, black	<i>Fraxinus nigra</i>
Ash, blue	<i>Fraxinus quadrangulata</i>
Ash, white	<i>Fraxinus americana</i>
Aspen, trembling	<i>Populus tremuloides</i>
Basswood	<i>Tilia americana</i>
Beech, blue	<i>Carpinus caroliniana</i>
Cherry, black	<i>Prunus serotina</i>
Coffee tree, Kentucky	<i>Gymnocladus dioica</i>
Cottonwood	<i>Populus deltoides</i>
Dogwood, flowering	<i>Cornus florida</i>
Elm, red	<i>Ulmus fulva</i>
Elm, white	<i>Ulmus americana</i>
Fir, Douglas	<i>Pseudotsuga taxifolia</i>
Hawthorn	<i>Crataegus</i> sp.
Hickory, bitternut	<i>Carya cordiformis</i>
Hickory, mockernut	<i>Carya ovata</i>
Hickory, pignut	<i>Carya glabra</i>

COMMON NAME	SCIENTIFIC NAME
Ironwood	<i>Ostrya virginiana</i>
Juneberry	<i>Amelanchier canadensis</i>
Maple, red	<i>Acer rubrum</i>
Maple, sugar	<i>Acer saccharum</i>
Oak, black	<i>Quercus velutina</i>
Oak, bur	<i>Quercus macrocarpa</i>
Oak, chinquapin	<i>Quercus Mühlenbergii</i>
Oak, northern red	<i>Quercus borealis</i> var. <i>maxima</i>
Oak, swamp white	<i>Quercus bicolor</i>
Oak, white	<i>Quercus alba</i>
Pine, Scotch	<i>Pinus sylvestris</i>
Pine, white	<i>Pinus strobus</i>
Poplar, yellow	<i>Liriodendron tulipifera</i>
Sassafras	<i>Sassafras albidum</i>
Walnut, black	<i>Juglans nigra</i>

**TABLE I**  
**EFFECT OF MANAGEMENT UPON THE TOTAL STEMS PER ACRE**

Species	All trees				Sawlog trees 10" DBH or more			
	1917	1942	In-crease	De-crease	1917	1942	In-crease	De-crease
	No.	No.	Pct.	Pct.	No.	No.	Pct.	Pct.
<b>COMPARTMENTS 1-5</b>								
<i>Commercial</i>								
Red oak*	35.9	30.4		15.3	20.7	19.1		7.7
White oak†	16.9	18.9	11.8		4.8	5.4	12.5	
Ash‡	43.4	99.1	128.3		1.9	1.8		5.3
Basswood	92.3	84.3		8.7	1.7	1.0		41.2
Sugar maple	20.1	57.7	187.1		2.5	1.7		32.0
Elm§	73.4	39.8		45.8	1.1	1.0		9.1
Black cherry	5.2	10.1	94.2		0.3	0.2		33.3
Black walnut	2.6	3.2	23.1		1.1	1.5	36.4	
Hickory	50.7	39.6		21.9	5.2	7.5	44.2	
Total	340.5	383.1	12.5		39.3	39.2		0.3
<i>Miscellaneous</i>								
Other	26.0	20.0		23.1	0.2	0.3	50.0	
Ironwood	433.6	195.1		55.0	0.1	0.0		100.0
Total	459.6	215.1		53.2	0.3	0.3		
<b>COMPARTMENTS 6-10</b>								
<i>Commercial</i>								
Red oak*	39.0	42.8	9.7		22.9	21.7		5.2
White oak†	14.3	13.9		2.8	3.7	4.7	27.0	
Ash‡	23.2	76.5	229.7		1.6	1.1		31.2
Basswood	67.3	93.5	38.9		1.2	1.0		16.7
Sugar maple	12.0	18.6	55.0		3.6	2.7		25.0
Elm§	36.6	40.3	10.1		1.1	1.3	18.2	
Black cherry	21.4	53.1	148.1		0.3	0.2		33.3
Black walnut	4.4	7.0	59.1		0.8	0.8		
Hickory	37.2	33.8		9.1	9.4	9.6	2.1	
Total	255.4	379.5	48.6		44.6	43.1		3.4
<i>Miscellaneous</i>								
Other**	35.6	24.6		30.9	0.7	0.6		14.3
Ironwood	87.5	125.6	43.5		0.0	0.0		
Total	123.1	150.2	22.0		0.7	0.6		14.3
<b>COMPARTMENTS 1-10</b>								
<i>Commercial</i>								
Red oak*	37.4	36.6		2.1	21.8	10.4		6.4
White oak†	15.6	16.4	5.1		4.3	5.1	18.6	
Ash‡	33.3	87.8	163.7		1.7	1.4		17.6
Basswood	79.8	88.9	11.4		1.4	1.0		28.6
Sugar maple	16.1	38.1	136.6		3.0	2.2		26.7
Elm§	55.0	40.0		27.3	1.1	1.2	9.1	
Black cherry	13.3	31.6	137.6		0.3	0.2		33.3
Black walnut	3.5	5.1	45.7		0.9	1.2	33.3	
Hickory	44.0	36.7		16.6	7.3	8.5	16.4	
Total	298.0	381.2	27.9		41.8	41.2		1.4
<i>Miscellaneous</i>								
Other††	30.8	22.3		27.6	0.5	0.4		20.0
Ironwood	260.5	160.3		38.5	0.1	0.0		100.0
Total	291.3	182.6		37.3	0.6	0.4		33.3

TABLE II

NUMBER, BASAL AREA, AND VOLUME OF TREES CUT PER ACRE DURING THE PERIOD 1917-42

Size Class	Total trees	Total basal area	Total gross volume	
	Number	Square feet	Cu. ft.	Bd. ft.*
COMPARTMENTS 1-5				
Reproduction.....	418.3	8.150	170.8	...
Small poles.....	54.7	7.035	127.4	...
Large poles.....	7.5	3.333	74.5	86
Standards.....	6.5	9.064	294.4	989
Veterans.....	2.9	13.779	483.3	1954
Total.....	489.9	41.361	1150.4	3029
COMPARTMENTS 6-10				
Reproduction.....	168.8	2.851	59.7	...
Small poles.....	29.7	4.297	76.5	...
Large poles.....	7.4	3.438	77.2	121
Standards.....	5.6	7.721	233.9	859
Veterans.....	1.7	7.892	275.7	1125
Total.....	213.2	26.199	723.0	2105
COMPARTMENTS 1-10				
Reproduction.....	293.5	5.498	115.2	...
Small poles.....	42.1	5.666	102.0	...
Large poles.....	7.5	3.386	75.9	104
Standards.....	6.0	8.394	264.0	918
Veterans.....	2.3	10.838	379.4	1540
Total.....	351.4	33.782	936.5	2562

\* Scribner Log Rule.

## NOTES TO TABLE I

\* Includes black oak.

† Includes swamp white, bur, and chinquapin oaks.

‡ Mostly white ash (on 21.5 acres 4 out of a total of 2,130 stems were black ash).

§ Includes both American and red elms.

|| Principally dogwood (56 per cent), blue beech (23 per cent), and soft maple (16 per cent). The remainder (5 per cent) is Amelanchier, aspen, cottonwood, Kentucky coffee tree, and sassafras.

¶ Predominantly white ash (on 21.5 acres 1,644 ash were tallied. Of this total 1,410 were white ash, 190 blue ash, and 44 black ash).

\*\* Principally dogwood (38 per cent), blue beech (42 per cent), and soft maple (17 per cent). The remainder (3 per cent) is butternut and tulip poplar.

†† Mostly dogwood (46 per cent), blue beech (33 per cent), and soft maple (17 per cent). The balance (4 per cent) is butternut, Kentucky coffee tree, aspen, Amelanchier, sassafras, cottonwood, and tulip poplar.

**TABLE III**  
**TOTAL BASAL AREA AND GROSS VOLUME PER ACRE PRIOR TO THE FIRST CUTTING AND AFTER THE FINAL CUTTING**

Size Class*	TOTAL GROSS VOLUME					
	Total basal area		Cubic feet		Board feet†	
	Before the first cut †	After the last cut ‡	Before the first cut †	After the last cut ‡	Before the first cut †	After the last cut ‡
COMPARTMENTS 1-5						
Reproduction.....	11,905	8,806	249.2	188.5	...	..
Small poles.....	10,449	9,697	190.4	164.2	..	421
Large poles.....	14,021	11,258	321.1	259.5	491	3822
Standards.....	28,770	36,125	849.9	1084.2	2889	1085
Veterans.....	17,703	7,768	617.4	264.8	2552	5328
Total.....	82,848	73,654	2228.0	1961.2	5932	
COMPARTMENTS 6-10						
Reproduction.....	4,146	6,952	85.5	149.1	...	...
Small poles.....	8,257	7,017	144.1	118.4	...	...
Large poles.....	15,518	12,038	358.5	276.9	615	453
Standards.....	34,448	37,047	1025.1	1102.3	3497	3817
Veterans.....	15,708	12,203	555.3	417.5	2279	1713
Total.....	78,077	75,257	2168.5	2064.2	6391	5983
COMPARTMENTS 1-10						
Reproduction.....	8,026	7,879	167.4	168.8	...	...
Small poles.....	9,353	8,357	167.2	141.3	...	...
Large poles.....	14,770	11,648	339.8	268.2	553	437
Standards.....	31,609	36,586	937.5	1093.2	3193	3819
Veterans.....	16,705	9,985	586.3	341.2	2416	1399
Total.....	80,463	74,455	2198.2	2012.7	6162	5655

\* Reproduction, 1-3 inches in diameter; small poles, 4-7 inches; large poles, 8-11 inches; standards, 12-22 inches; veterans, 23 inches and larger.

† Silvicultural cuttings were initiated in compartments 1-5 in 1917 and in compartments 6-10 in 1922.

‡ The final cuttings in compartments 1-5 and 6-10 were made in the winter of 1942-43.

§ By the Scribner Log Rule.



**TABLE IV**  
**GROSS CUBIC-FOOT AND BOARD-FOOT VOLUMES PER ACRE BY SPECIES AND**  
**D.B.H. CLASSES AT THE END OF 1942**

Species	D B.H. class in inches									
	1-3	4-7	8-11	12-22	23 or more	Total				
	GROSS VOLUME*									
	Cu. ft.	Cu. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.
COMPARTMENTS 1-5										
Commercial										
Red oak	4.0	2.6	49.5	110	651.7	2321	95.6	406	803.4	2837
White Oak	3.7	10.8	36.4	50	128.1	438	112.6	446	291.6	934
Ash	34.0	22.9	13.9	21	42.6	148	10.2	43	123.6	212
Basswood	27.4	38.4	21.3	16	13.6	43	16.9	70	117.6	129
Sugar maple	18.0	7.9	10.5	17	41.6	141	17.0	70	95.0	228
Elm	13.3	24.1	18.4	25	16.3	58	0.0	0	70.1	83
Black cherry	2.3	2.3	0.6	2	7.2	27	0.0	0	12.4	29
Black walnut	0.4	1.6	4.9	11	53.2	196	12.5	50	72.6	257
Hickory	8.0	25.9	100.7	164	124.4	430	0.0	0	259.0	594
Total	111.1	136.5	254.2	416	1078.7	3802	264.8	1085	1845.3	5303
Miscellaneous										
Other	4.1	6.5	5.3	5	5.5	20	0.0	0	21.4	25
Ironwood	73.3	21.2	0.0	0	0.0	0	0.0	0	94.5	0
Total	77.4	27.7	5.3	5	5.5	20	0.0	0	115.9	25
Grand total	188.5	164.2	259.5	421	1084.2	3822	264.8	1085	1961.2	5328
COMPARTMENTS 6-10										
Commercial										
Red oak	6.3	5.7	81.6	166	630.7	2194	140.3	589	864.6	2949
White oak	1.0	12.7	30.6	47	90.0	330	218.9	883	353.2	1260
Ash	26.8	12.1	5.4	8	35.6	125	0.0	0	79.9	133
Basswood	32.6	30.4	10.5	10	17.1	57	21.3	90	111.9	157
Sugar maple	4.4	2.8	19.5	37	51.5	164	4.8	21	83.0	222
Elm	13.5	18.5	20.3	21	24.4	84	21.5	85	98.2	190
Black cherry	18.0	8.9	3.9	4	6.0	21	0.0	0	36.8	25
Black walnut	1.8	4.5	3.5	2	38.4	146	0.0	0	48.2	148
Hickory	4.5	17.0	97.0	153	196.7	656	0.0	0	315.2	809
Total	108.9	112.6	272.3	448	1090.4	3777	406.8	1668	1991.0	5893
Miscellaneous										
Other	5.6	2.9	4.3	5	11.9	40	10.7	45	35.4	90
Ironwood	34.6	2.9	0.3	0	0.0	0	0.0	0	37.8	0
Total	40.2	5.8	4.6	5	11.9	40	10.7	45	73.2	90
Grand total	149.1	118.4	276.9	453	1102.3	3817	417.5	1713	2064.2	5983
COMPARTMENTS 1-10										
Commercial										
Red oak	5.1	4.1	65.5	139	641.1	2258	118.0	497	833.8	2894
White oak	2.4	11.7	33.5	48	109.1	383	165.8	664	322.5	1095
Ash	30.4	17.5	9.6	14	39.1	137	5.1	22	101.7	173
Basswood	30.1	34.5	15.9	13	15.3	50	19.1	80	114.9	143
Sugar maple	11.2	5.4	15.0	27	46.5	152	10.9	46	89.0	225
Elm	13.3	21.4	18.4	23	20.3	71	10.8	43	84.2	137
Black cherry	10.1	5.5	2.3	3	6.6	24	0.0	0	24.5	27
Black walnut	1.1	3.1	4.2	6	45.8	171	6.2	25	60.4	202
Hickory	6.2	21.6	98.8	159	160.7	543	0.0	0	287.3	702
Total	109.9	124.8	263.2	432	1084.5	3789	335.9	1377	1918.3	5598
Miscellaneous										
Other	4.9	4.6	4.8	5	8.7	30	5.3	22	28.3	57
Ironwood	54.0	11.9	0.2	0	0.0	0	0.0	0	66.1	0
Total	58.9	16.5	5.0	5	8.7	30	5.3	22	94.4	57
Grand total	168.8	141.3	268.2	437	1093.2	3819	341.2	1399	2012.7	5655

\* Cubic foot volume is the total volume in all trees from 1 inch to 36 inches; board-foot volume is merchantable volume by the Scribner Log Rule.

TABLE V  
NUMBER AND PERCENTAGE OF TREES, BY D.B.H. CLASSES AND SPECIES, REMOVED PER ACRE DURING THE PERIOD 1917-42

Species	D.B.H. class in inches											
	1-3			4-7			8-11			12-22		
	No.	Pct.		No.	Pct.		No.	Pct.		No.	Pct.	Total
COMPARTMENTS 1-5												
<i>Commercial</i>												
Red oak*	0.4	9.1	0.5	11.4	1.1	25.0	1.8	40.9	0.6	13.6	4.4	100.0
White oak	2.9	40.8	2.4	33.8	0.7	9.9	0.4	5.6	0.7	9.9	7.1	100.0
Ash†	10.0	84.8	1.1	9.3	0.4	3.4	0.3	2.5	0.0	0.0	11.8	100.0
Basswood	30.6	78.5	5.4	13.8	0.7	1.8	1.1	2.8	1.2	3.1	39.0	100.0
Sugar maple	3.4	59.6	0.7	12.3	0.5	8.8	1.1	19.3	0.0	0.0	5.7	100.0
Elm†	24.3	82.9	3.7	12.6	0.5	1.7	0.5	1.7	0.3	1.0	29.3	100.0
Black cherry	7.5	89.3	0.7	8.3	0.1	1.2	0.1	1.2	0.0	0.0	8.4	100.0
Black walnut	0.0	0.0	0.1	33.3	0.1	33.3	0.1	33.4	0.0	0.0	0.3	100.0
Hickory	9.6	46.6	7.4	35.9	2.5	12.1	1.0	4.9	0.1	0.5	20.6	100.0
Total	88.7	70.0	22.0	17.4	6.6	5.2	6.4	5.1	2.9	2.3	126.6	100.0
<i>Miscellaneous</i>												
Other‡	21.3	95.1	1.0	4.5	0.0	0.0	0.1	0.4	0.0	0.0	22.4	100.0
Ironwood	308.3	90.4	31.7	9.3	0.9	0.3	0.0	0.0	0.0	0.0	340.9	100.0
Total	329.6	90.8	32.7	9.0	0.9	0.2	0.1	0.0	0.0	0.0	363.3	100.0
Grand Total	418.3	85.4	54.7	11.2	7.5	1.5	6.5	1.3	2.9	0.6	489.9	100.0
COMPARTMENTS 6-10												
<i>Commercial</i>												
Red oak*	0.7	9.2	1.9	25.0	2.6	34.2	2.2	28.9	0.2	2.7	7.6	100.0
White oak	0.8	16.7	2.8	58.3	0.2	4.2	0.0	1.0	0.0	20.8	4.8	100.0
Ash†	6.9	84.1	0.8	9.8	0.3	3.7	0.1	1.2	0.1	1.2	8.2	100.0
Basswood	17.7	96.2	0.5	2.7	0.0	0.0	0.0	0.0	0.2	1.1	18.4	100.0
Sugar maple	4.1	59.4	1.1	16.0	1.0	14.5	0.7	10.1	0.0	0.0	6.9	100.0
Elm†	23.3	88.9	2.3	8.8	0.3	1.1	0.1	0.4	0.2	0.8	26.2	100.0
Black cherry	15.5	95.7	0.3	1.9	0.0	0.0	0.4	2.4	0.0	0.0	16.2	100.0
Black walnut	0.0	0.0	0.0	0.0	0.0	0.0	0.5	100.0	0.0	0.0	0.5	100.0
Hickory	5.4	22.9	13.8	58.5	2.8	11.8	1.6	6.8	0.0	0.0	23.6	100.0
Total	74.4	66.2	23.5	20.9	7.2	6.4	5.6	5.0	1.7	1.5	112.4	100.0
<i>Miscellaneous</i>												
Other‡	22.1	96.1	0.9	3.9	0.0	0.0	0.0	0.0	0.0	0.0	23.0	100.0
Ironwood	72.3	92.9	5.3	6.8	0.2	0.3	0.0	0.0	0.0	0.0	77.8	100.0
Total	94.4	93.7	6.2	6.1	0.2	0.2	0.0	0.0	0.0	0.0	100.8	100.0
Grand total	168.8	79.2	29.7	13.9	7.4	3.5	5.6	2.6	1.7	0.8	213.2	100.0

TABLE V (concluded)

Species	D.B.H. class in inches									
	1-3		4-7		8-11		12-22		23 and larger	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
COMPARTMENTS 1-10										
<i>Commercial</i>										
Red oak*	0.6	10.5	1.0	17.6	1.7	29.8	2.0	35.1	0.4	7.0
White oak	1.8	31.6	2.4	42.1	0.5	8.8	0.2	3.5	0.8	14.0
Ash†	8.8	84.6	1.0	9.6	0.3	2.9	0.2	1.9	0.1	1.0
Basswood	24.6	83.7	3.2	10.9	0.4	1.3	0.5	1.7	0.7	2.4
Sugar maple	3.8	61.3	0.8	12.9	0.7	11.3	0.9	14.5	0.0	0.0
Elm‡	24.4	86.2	3.0	10.6	0.4	1.4	0.3	1.1	0.2	0.7
Black cherry	12.1	93.8	0.5	3.9	0.1	0.8	0.2	1.5	0.0	0.0
Black walnut	0.0	0.0	0.0	0.0	0.1	25.0	0.3	75.0	0.0	0.0
Hickory	7.6	35.9	9.5	44.8	2.7	12.7	1.3	6.1	0.1	0.5
Total	83.7	69.7	21.4	17.8	6.9	5.7	5.9	4.9	2.3	1.9
<i>Miscellaneous</i>										
Other§	22.3	95.7	0.9	3.9	0.0	0.0	0.1	0.4	0.0	0.0
Ironwood	187.5	90.2	19.8	9.5	0.6	0.3	0.0	0.0	0.0	0.0
Total	209.8	90.7	20.7	9.0	0.6	0.3	0.1	0.0	0.0	0.0
Grand total	293.5	83.5	42.1	12.0	7.5	2.1	6.0	1.7	2.3	0.7

\* Includes black oak.

† Predominantly white ash.

‡ Includes both American and red elms.

§ Includes blue beech, soft maple, butternut, hawthorn, dogwood, and sassafras.

TABLE VI  
NUMBER AND PERCENTAGE OF TREES, BY SPECIES AND D.B.H. CLASSES, REMOVED PER ACRE DURING THE PERIOD 1917-42

Species	D.B.H. class in inches											
	1-3			4-7			8-11			12-22		
	No.	Pct.		No.	Pct.		No.	Pct.		No.	Pct.	
COMPARTMENTS 1-5												
<i>Commercial</i>												
Red oak*	0.4	0.1		0.5	0.9		1.1	14.7		1.8	27.7	
White oak	2.9	0.7		2.4	4.4		0.7	9.3		0.4	6.2	
Ash†	10.0	2.4		1.1	2.0		0.4	5.4		0.3	4.6	
Basswood	30.6	7.3		5.4	9.9		0.7	9.3		1.1	16.9	
Sugar maple	3.4	0.8		0.7	1.3		0.5	6.7		1.1	16.9	
Elm†	24.3	5.8		3.7	6.8		0.5	6.7		0.5	7.7	
Black cherry	7.5	1.8		0.7	1.3		0.1	1.3		0.1	1.5	
Black walnut	0.0	0.0		0.1	0.2		0.1	1.3		0.1	1.5	
Hickory	9.6	2.3		7.4	13.5		2.5	33.3		1.0	15.5	
Total	88.4	21.2		22.0	40.3		6.6	88.0		6.4	98.5	
<i>Miscellaneous</i>												
Other‡	21.3	5.1		1.0	1.8		0.0	0.0		0.1	1.5	
Ironwood	308.3	73.7		31.7	57.9		0.9	12.0		0.0	0.0	
Total	329.6	78.8		32.7	59.7		0.9	12.0		0.1	1.5	
Grand total	418.3	100.0		54.7	100.0		7.5	100.0		6.5	100.0	
COMPARTMENTS 6-10												
<i>Commercial</i>												
Red oak*	0.7	0.4		1.9	6.4		2.6	35.1		2.2	39.3	
White oak	0.8	0.5		2.8	9.4		0.2	2.7		0.0	0.0	
Ash†	6.9	4.1		0.8	2.7		0.3	4.1		0.1	1.8	
Basswood	17.7	10.5		0.5	1.7		0.0	0.0		0.0	0.0	
Sugar maple	4.1	2.4		1.1	3.7		1.0	13.5		0.7	12.5	
Elm†	23.3	13.8		2.3	7.8		0.3	4.1		0.1	1.8	
Black cherry	15.5	9.2		0.3	1.0		0.0	0.4		0.4	7.1	
Black walnut	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Hickory	5.4	3.2		13.8	46.5		2.8	37.8		1.6	8.9	
Total	74.4	44.1		23.5	79.2		7.2	97.3		5.6	100.0	
<i>Miscellaneous</i>												
Other‡	22.1	13.1		0.9	3.0		0.0	0.0		0.0	0.0	
Ironwood	72.3	42.8		5.3	17.8		0.2	2.7		0.0	0.0	
Total	94.4	55.9		6.2	20.8		0.2	2.7		0.0	0.0	
Grand total	168.8	100.0		29.7	100.0		7.4	100.0		5.6	100.0	

TABLE VI (concluded)

Species	D.B.H. class in inches											
	1-3		4-7		8-11		12-22		23 and larger		Total	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
COMPARTMENTS 1-10												
<i>Commercial</i>												
Red oak* . . . . .	0.6	0.2	1.0	2.4	1.7	22.8	2.0	33.3	0.4	17.4	5.7	1.6
White oak . . . . .	1.8	0.6	2.4	5.7	0.5	6.7	0.2	3.3	0.8	34.8	5.7	1.6
Ash† . . . . .	8.8	3.0	1.0	2.4	0.3	4.0	0.2	3.3	0.1	4.4	10.4	3.0
Basswood . . . . .	24.6	8.4	3.2	7.6	0.4	5.3	0.5	8.3	0.7	30.4	29.4	8.4
Sugar maple . . . . .	3.8	1.3	0.8	1.9	0.7	9.3	0.9	15.0	0.0	0.0	6.2	1.8
Elm† . . . . .	24.4	8.3	3.0	7.1	0.4	5.3	0.3	5.0	0.2	8.7	28.3	8.1
Black cherry . . . . .	12.1	4.1	0.5	1.2	0.1	1.3	0.2	3.3	0.0	0.0	12.9	3.7
Black walnut . . . . .	0.0	0.0	0.0	0.0	0.1	1.3	0.3	5.0	0.0	0.0	0.4	0.1
Hickory . . . . .	7.6	2.6	9.5	22.6	2.7	36.0	1.3	21.8	0.1	4.3	21.2	6.0
Total . . . . .	83.7	28.5	21.4	50.9	6.9	92.0	5.9	98.3	2.3	100.0	120.2	34.3
<i>Miscellaneous</i>												
Others . . . . .	22.3	7.6	0.9	2.1	0.0	0.0	0.1	1.7	0.0	0.0	23.3	6.6
Ironwood . . . . .	187.5	63.9	19.8	47.0	0.6	8.0	0.0	0.0	0.0	0.0	207.9	59.1
Total . . . . .	209.8	71.5	20.7	49.1	0.6	8.0	0.1	1.7	0.0	0.0	231.2	65.7
Grand total . . . . .	293.5	100.0	42.1	100.0	7.5	100.0	6.0	100.0	2.3	100.0	351.4	100.0

**\* Includes black oak.**

† Predominantly white ash.

**It Includes both American and red elms.**

§ Includes blue beech, soft maple, butternut, hawthorn, dogwood, and sassafras.

**TABLE VII**  
**GROSS MEAN ANNUAL INCREMENT PER ACRE FOR THE PERIOD 1917-42**

Item	Total basal area	Total gross volume	
	Square feet	Cu. ft.	Bd. ft.*
Compartments 1-5			
1. Stand at end of 1942 . . . . .	73.654	1,961.2	5,328
2. Material removed, 1917-42 . . . . .	41.361	1,150.4	3,029
3. Total . . . . .	115.015	3,111.6	8,357
4. Stand in 1917 before cutting . . . . .	83.848	2,228.0	5,932
5. Difference . . . . .	32.167	883.6	2,425
6. Mean annual increment for 25 years . .	1.287	35.3	97
Compartments 6-10			
1. Stand at end of 1942 . . . . .	75.257	2,064.2	5,983
2. Material removed, 1917-42 . . . . .	26.199	723.0	2,105
3. Total . . . . .	101.456	2,787.2	8,088
4. Stand in 1917 before cutting . . . . .	78.077	2,168.5	6,391
5. Difference . . . . .	23.379	618.7	1,697
6. Mean annual increment for 25 years . .	0.935	24.9	68
Compartments 1-10			
1. Stand at end of 1942 . . . . .	74.455	2,012.7	5,655
2. Material removed, 1917-42 . . . . .	33.782	936.5	2,562
3. Total . . . . .	108.237	2,949.2	8,217
4. Stand in 1917 before cutting . . . . .	80.463	2,198.2	6,162
5. Difference . . . . .	27.774	751.0	2,055
6. Mean annual increment for 25 years . .	1.111	30.0	82

\* Scribner Log Rule.







**I. A. R. I. 75.**

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